

1975

The Application of the Haccp Concept to the Breaded Shrimp Industry.

William Clifford Hopkins Jr

Louisiana State University and Agricultural & Mechanical College

Follow this and additional works at: https://digitalcommons.lsu.edu/gradschool_disstheses

Recommended Citation

Hopkins, William Clifford Jr, "The Application of the Haccp Concept to the Breaded Shrimp Industry." (1975). *LSU Historical Dissertations and Theses*. 2873.

https://digitalcommons.lsu.edu/gradschool_disstheses/2873

This Dissertation is brought to you for free and open access by the Graduate School at LSU Digital Commons. It has been accepted for inclusion in LSU Historical Dissertations and Theses by an authorized administrator of LSU Digital Commons. For more information, please contact gradetd@lsu.edu.

INFORMATION TO USERS

This material was produced from a microfilm copy of the original document. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the original submitted.

The following explanation of techniques is provided to help you understand markings or patterns which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting thru an image and duplicating adjacent pages to insure you complete continuity.
2. When an image on the film is obliterated with a large round black mark, it is an indication that the photographer suspected that the copy may have moved during exposure and thus cause a blurred image. You will find a good image of the page in the adjacent frame.
3. When a map, drawing or chart, etc., was part of the material being photographed the photographer followed a definite method in "sectioning" the material. It is customary to begin photoing at the upper left hand corner of a large sheet and to continue photoing from left to right in equal sections with a small overlap. If necessary, sectioning is continued again -- beginning below the first row and continuing on until complete.
4. The majority of users indicate that the textual content is of greatest value, however, a somewhat higher quality reproduction could be made from "photographs" if essential to the understanding of the dissertation. Silver prints of "photographs" may be ordered at additional charge by writing the Order Department, giving the catalog number, title, author and specific pages you wish reproduced.
5. PLEASE NOTE: Some pages may have indistinct print. Filmed as received.

Xerox University Microfilms

300 North Zeeb Road
Ann Arbor, Michigan 48106

76-12,918

HOPKINS, William Clifford, Jr., 1944-
THE APPLICATION OF THE HACCP CONCEPT
TO THE BREADED SHRIMP INDUSTRY.

The Louisiana State University and
Agricultural and Mechanical College
Ph.D., 1975
Food Technology

Xerox University Microfilms, Ann Arbor, Michigan 48106

© 1976

WILLIAM CLIFFORD HOPKINS, Jr.

ALL RIGHTS RESERVED

THIS DISSERTATION HAS BEEN MICROFILMED EXACTLY AS RECEIVED.

**THE APPLICATION OF THE HACCP CONCEPT
TO THE BREADED SHRIMP INDUSTRY**

A Dissertation

**Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy**

in

The Department of Food Science

**by
William Clifford Hopkins, Jr.
B.S., Louisiana State University, 1968
M.S., Louisiana State University, 1970
December, 1975**

ACKNOWLEDGMENT

The author wishes to express sincere gratitude to his major professor, Dr. Arthur F. Novak, for his advice and guidance during the course of this investigation. Appreciation is also extended to Dr. Joseph A. Liuzzo, Dr. Robert M. Grodner, Dr. M. M. R. Rao, Dr. William H. James, and Dr. Theodore B. Ford for serving on his examining committee.

A special thanks is made to Mr. Mas Kawaguchi, Mr. Donald J. Toloday and Dr. Rafael R. Pedraja for their cooperative assistance.

Gratitude is also expressed to Mr. R. L. Carroll, architect, for his technical assistance.

The author wishes to express his indebtedness to the Louisiana State University for financial support of this project and to all the professors in the Department of Food Science for their many assistances.

A special word of thanks to the family and friends of the author who gave their support to him while this project was being completed.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENT	ii
LIST OF TABLES	iv
LIST OF FIGURES	v
LIST OF DIAGRAMS	vi
ABSTRACT	vii
INTRODUCTION	1
Chapter	
1. REVIEW OF LITERATURE	5
2. EXPERIMENTAL IMPLEMENTATION OF HACCP	36
3. HAZARD ANALYSIS OF MARINE OPERATIONS	45
4. HAZARDS ASSOCIATED WITH SHRIMP PACKING	57
5. HAZARDS FROM RECEPTION THROUGH PRODUCT PREPARATION	64
6. HAZARDS IN THE BREADING OPERATION	72
7. PRESERVATION OPERATIONS	77
8. CASING THROUGH DISTRIBUTION	83
9. SPECIAL HAZARDS	87
10. DISCUSSION	100
SUMMARY	115
BIBLIOGRAPHY	121
APPENDIX	126
VITA	134

LIST OF TABLES

Table	Page
I. Shipboard HACCP	47
II. Shrimp Packer HACCP	57
III. Product Preparation HACCP	67
IV. Packing and Preservation HACCP	77
V. Distributive and Consumer HACCP	83
VI. Special Plant HACCP	88

LIST OF FIGURES

Figure	Page
1. Shrimp boats in the harbor	48
2. Shrimp trawler	49
3. Proper handling of crushed ice	54
4. A sanitizing dip for ice shovel	55
5. Shrimp graders after cleaning	61
6. The peeling and deveining operation process of shrimp for breaded shrimp	69
7. The shrimp being sorted before breeding	74
8. The application of batter and breeding to the shrimp	75
9. Packing breaded shrimp	79
10. A packing line for breaded shrimp	80
11. A hand washing station	94
12. An iodine dip solution for hands	95
13. A clean, well-lit locker room	96
14. Dipping hands in iodine solution	106
15. Inspection of equipment	107
16. High pressure cleaning of equipment	108
17. Cleaning batter equipment	109
18. Inspection of hands before starting work	110
19. Icing of shrimp during processing	111
20. Dipping hands in iodine solution	112

LIST OF DIAGRAMS

Diagram	Page
1. Flow diagram for frozen raw breaded shrimp	38
2. Hazards in marine operation	46
3. Hazard analysis at primary packer	58
4. Hazard analysis for receiving and washing operations	65
5. Hazard analysis of product preparation operations	66
6. Preservation hazards	78
7. Hazards of distribution	84

ABSTRACT

New laws being enforced by the U.S. Food and Drug Administration require the development of specialized quality assurance techniques for inspecting and approving each type of food processing industry. A new concept called "Hazard Analysis Critical Control Points" (HACCP) is being emphasized as a regulatory procedure for plant evaluation. This investigation was designed to develop specific inspectional procedures for locating HACCP's and to devise methods for their control during the manufacture of frozen raw breaded shrimp.

The principle involved in HACCP is to treat the entire food manufacturing process and its environment as a single system. When this concept is applied, the first requirement is to develop an inventory or list of hazard producing operations, followed by subsequent elimination of all potential dangers that can be removed. The final activity is the implementation of controls for those hazards which cannot be eliminated.

In searching for HACCP areas during the manufacture of frozen raw breaded shrimp, investigations were made at every location where the product could have been damaged, contaminated, or adulterated from the time the shrimp were removed from the water until they reached the retail outlets. Therefore, in developing this HACCP program for frozen raw

breaded shrimp, it was necessary to study the flow of shrimp from shipboard through preparation, processing, packaging, freezing, and distribution.

Application of this HACCP concept was accomplished by the use of current inspectional techniques, record keeping, operational analysis, and organizational consultation. This requires the continuous participation of the technical staff, the production staff, and higher level management.

Identification of bacterial and pathogenic hazards was performed periodically in plant investigations during a period of 30 months. During this period, over 600 bacterial analyses were made to identify the various hazards and their locations. Microbiological tests were made for total plate count, total coliforms, Escherichia coli, coagulase positive Staphylococcus, and Salmonella-Shigella, in accordance with FDA guidelines for frozen raw breaded shrimp.

Results from these tests identified the widespread problems. Some hazards were found to be very specific in their location, while others occurred throughout the entire processing environment. Also, the data showed problems found in the study were specific to the plant involved, and that most hazards can be controlled by continuous monitoring through quality assurance tests.

Implementation of the HACCP concept produces a plan for the elimination and control of hazards. A basic plan which can be altered to fit any plant in which it is being

applied, is composed of systems for raw product evaluation, equipment and personnel sanitation control, and continuous monitoring of operational practices. When applied with Good Manufacturing Practices, the plan identifies the hazards, their degree of severity, and the means for applying methods of control. Any new problem that develops must be evaluated rapidly and brought under scientific control.

If any manufacturer of frozen raw breaded shrimp uses this plan for an HACCP program, it should be relatively simple to make any necessary modifications, and achieve the desired hazard control program.

INTRODUCTION

The primary responsibility for food safety is with the food processor or packer, and it is a function of the United States Food and Drug Administration (FDA) to see that this obligation is discharged. The FDA accomplishes this through six types of activities: (1) inspection, (2) regulation, (3) regulatory surveillance, (4) informational surveillance, (5) monitoring of voluntary codes of practice, and (6) education. It has been stated by the agency that all of these measures are employed when investigating the quality control systems used by a food industry in fulfilling its responsibility.

Quality Assurance may be defined as the design, management and monitoring of the organized system which controls those production factors that determine the compliance of a product with the official standards or guidelines for the product. Some of these factors are: (1) health hazards and sanitation, including micro-organisms, molds, mycotoxins, heavy metals, naturally occurring toxins, industrial chemicals, pesticides, nutritional losses, and basic sanitary practices; (2) regulatory hazards including fraudulent practices, improper labeling, and improper additives; and (3) economic hazards such as over fill line wastes, high spoilage and unnecessary ingredients.

The FDA is primarily concerned with the adequacy of these controls. The system that has been developed for the evaluation of these controls by the FDA is referred to as the Hazard Analysis Critical Control Points system (HACCP).

In discussing HACCP, it is obvious that several questions should arise. What is the present status of food-borne disease, and has the frequency of occurrence increased or decreased? What can be and is being done to control food-borne disease, and how does HACCP apply to this control in the production of any particular food product?

HACCP is the investigational technique for the identification, elimination and/or control of those factors which may give rise to a health hazard when the food is consumed. It is the introduction of food safety into the product by a systematic control method.

The concept begins with the raw materials and follows them through to the final product. Major factors involved include raw materials, equipment design and sanitation, personnel sanitation, process control and practices, storage, distribution, plant construction and maintenance including the land use around the building.

HACCP is being instituted to (1) improve the inspectional system of the FDA, (2) stop the increasing number of Good Manufacturing Practices violations, and (3) assist the industry in its self evaluation of food safety problems, one of which is food-borne disease.

Bryan (4) found that "the status of food-borne disease has remained unchanged over the years since the reporting of food-borne disease was first begun." He goes on to state that "there has been no evidence of any decrease in the incidence of food-borne disease."

Various observers have different viewpoints about progress made in the area of microbiological food safety. Some consumer groups believe that the situation of food safety is so severe that it presents an immediate and serious threat to the health of the consumer. Some of the industrial groups feel that the situation is satisfactory and cannot be improved upon without drastic increases in the cost of production compared to minimal degree of improvement in quality of the product. Until 1973, there was much discussion of the situation, and some trial programs were instituted. In 1973, the FDA applied the Hazard Analysis Critical Control Points concept of the National Aeronautics and Space Administration to the low acid canned food industry. The goal at present is to apply this concept to other segments of the food industry, with the objective of achieving a better level of food safety.

This dissertation is an investigation of how the HACCP concept applies to the frozen breaded shrimp industry. This segment of the food industry will be brought under HACCP in the near future, because: (1) breaded shrimp is a good medium for bacterial growth; (2) its method of preparation

does not result in a sterilized product, but rather the retention of its bacterial content; and (3) past history of the product has implicated it in the outbreak of a number of food-borne diseases, which dictates a need to improve the effectiveness of quality assurance in this industry.

Chapter 1

REVIEW OF LITERATURE

Although a considerable amount of information on "Hazard Analysis Critical Control Points" (HACCP) is available in the literature, much of the material is repetitive and similar. Since the food and drug laws define the procedures for plant inspections, it is probably advisable to quote the official regulatory personnel who will be responsible for enforcing the new laws.

Robert Angelotti (1) of the Food and Drug Administration has said, "The consumer is entitled to the best quality product achievable within the technological feasibility of the systems that are involved in providing that product to the consumer." The viewpoint of industry was stated best by Raphael Pedraja (25): "Most important we must realize that profits can only be attained by a proper combination and balancing of factors: acceptable quality, production efficiency, a high degree of performance, and a good working relationships within all departments of the company." These two statements do not conflict as they first might appear to do, but rather, the second statement modifies the first. One way that we can help assure high quality foods is by utilization of the Hazard Analysis Critical Control Points

(HACCP) System (Kauffman, 14).

The consensus is that we should have a concerted effort by both the FDA and the food industries.

Before a system can be utilized, we need to know what it is and how it works. The Hazard Analysis Critical Control Points Concept can be described as a system of preventive control, particularly in relation to microbiological hazards. The concept was developed outside of the Food and Drug Administration (Bauman, 3). This concept is now being used by the FDA for low acid canned foods with a view toward possible application to all types of food packaging (40).

When applying the concept to a new segment of the industry, the term should be defined. Hazard analysis is the identification of sensitive ingredients, critical process points and relevant human factors as they affect product safety. Critical control points are those determiners whose loss of control would result in an unacceptable food safety risk (Bauman, 3).

Bauman states that the ingredients may be classified into five categories on the basis of descending risk. These are:

- (1) Foods intended for special populations such as infants and the elderly who are more susceptible to disease organisms.
- (2) Sensitive ingredients which can have a pronounced effect on food safety. Included are compound ingredients which have 30% or more of a sensitive ingredient.
- (3) Compound ingredients which contain 30% or less of sensitive ingredients. [This 30% level is really

arbitrary, but it should not be adjusted very far from this point because of the probability of a sensitive ingredient carrying harmful organisms into a mixture.]

- (4) Ingredients of agricultural origin not previously shown to be a source of harmful micro-organisms, chemicals or pesticide residues.
- (5) Ingredients historically free of pathogens or residue. These include sugar, salt, and other essentially pure chemicals.

The above system of classification has been applied to final products. The system as established by the National Academy of Sciences (18) is based on three major hazard characteristics:

(1) The product contains a sensitive ingredient or ingredients which can be assumed to be potential sources of contamination under normal circumstances.

(2) The manufacturing process does not contain a controlled processing step that effectively destroys harmful bacteria.

(3) There is substantial potential for microbiological abuse in distribution or in consumer handling that, as the result of microbial growth, could render the product harmful when consumed.

The product classification is based upon the combined response to the above characteristics. A code is set up based on the response of the product to each characteristic with plus (+) indicating the presence of the characteristic and zero (0) indicating its absence. The code is read as characteristics 1-2-3.

The categories are as follows:

"Category I. A special category of products designed and intended for consumption by infants, the aged, and the inform. There is no code.

Category II. Food products subject to all three general hazard characteristics. The code is +++.

Category III. Food products subject to two of the three general hazard characteristics. The codes are +0+, ++0, or 0++.

Category IV. Food products subject to one of the three general hazard characteristics. The codes are +00, 0+0, or 00+.

Category V. Food products subject to none of the general hazard characteristics. The code is 000" (NAS, 18).

The above classification includes the processing and distribution of the product.

Raw Materials Hazard Analysis

The microbiological hazards in the raw materials may come from two major sources. The first source includes both the shrimp as they are harvested, and the raw ingredients which go into the batter and breading. The second source of contamination is by packers, manufacturers, and distributors who mishandle the ingredients before delivery to the shrimp breading plant. The results of this mishandling cannot be undone by further processing.

When the ingredients and final product are examined

on the basis of the National Academy of Sciences criteria for hazard categories, the following results are obtained:

Shrimp - category 2

Batter - category 2

Breading - category 3.

The combination and content of the ingredients together with the process produce a final product which has the hazard characteristics of category 2.

The question of processing hazards is resolved by answering two other questions. According to Bauman (3), these are: (1) What is the bacterial load on incoming material at the plant? (2) How is that load affected during processing?

If the processing of a food item does not contain a controlled process step which effectively destroys harmful organisms, then a substantial food safety risk may exist (Bauman, 3).

The process for frozen breaded shrimp is, by definition, freezing. Although there is a general die-off of microbes during frozen storage, especially of some sensitive types of microorganisms, processors are well aware that the freezing process is not lethal and cannot be expected to sterilize food products (Peterson, 27).

As the frozen food leaves the processor, its microbial character and composition are indicative of the original microbial condition of the food, of equipment and personnel sanitation, of the processing treatment, of time-

temperature controls during processing, of good food handling practices, of general sanitation during production, and care in packing and freezing (27).

From the standpoint of hazard analysis, there are two basic components of the process:

- (1) The biological critical process point, defined as an operation in a given process which, if not maintained within certain parameters, can result in the production of food which may be unsafe from a microbiological standpoint.
- (2) The physical hazard control point, defined as an element of process equipment or environment of a process which, if not properly maintained and monitored, can result in the introduction of hazardous foreign materials into the product (Bauman, 3). The hazardous foreign materials are not within the scope of this study which is limited to the pathogenic bacteria in frozen raw breaded shrimp. This leaves only the biological factors for consideration.

Another general hazard to be considered is the potential for microbial abuse in distribution and consumer handling. The hazards in transportation, distribution, retailing and handling by the consumer may be more important than for other foods such as canned, heat processed or dehydrated foods (27). The principal judgment criterion for abuse is whether the food is a suitable medium for microbial growth in the state in which it is distributed or as it is normally prepared by the consumer (3).

According to Bauman (3), the assessment must include such parameters as the pH of the product, water activity, presence of chemical and microbial inhibitors, type and effectiveness of the food processing as it affects the microbial population, atmosphere within the package, and the

storage and distribution temperatures.

Bryan (5) has summarized the factors responsible for outbreaks (of food-borne disease) traced to foods mishandled in food service establishments, homes and food processing plants. Inadequate refrigeration practices were the chief operational procedures that have contributed to a large number of outbreaks. Other contributing procedures are:

(1) preparing far in advance of planned service with improper storage during the interval before serving, (2) infected persons touching foods after final heat processing, and (3) holding foods in warming devices that favor bacterial growth. This mishandling would be considered by food processors as consumer abuse. It is often difficult to make an unqualified assertion that mishandling in food processing plants is solely responsible for a disease outbreak.

Hazard analysis makes use of already developed evaluative techniques to determine how the consumer perceives and uses the product in order to try to predict what he might do with it, and what hazards might develop from that usage. This allows us to determine potential hazards that may not have been anticipated by research and development and may result in more precise information on the tolerance ranges we must have to ensure safety (Bauman, 3).

How does the HACCP concept work? There are three basic steps for adequate control. These are inventory of hazards, elimination of hazards, and the establishment of controls over those hazards which cannot be eliminated

(Bauman, 3).

Hazard Inventory

As indicated above, part of HACCP is knowledge of the product, process and raw materials. Hazard analysis begins with the development of a process flow diagram which includes all the pertinent processing factors and details, and is specific for the food, process, equipment, and plant involved.

Consideration must be given to other processes or materials in the same area of the plant or using the same equipment which could affect the process under investigation (Peterson, 26). The following items should be included as critical control points in the hazard analysis: (1) facility sanitation and maintenance, (2) equipment sanitation, (3) employee personal hygiene, (4) microbiological population critical control, and (5) microbial growth, including time-temperature relationships.

Facility Sanitation and Maintenance

In practice, sanitation starts with the physical surroundings and ends when the product is properly packed and stored (25). Rafael Pedraja points out that the physical surroundings have been given proper recognition in the Good Manufacturing Regulations issued under the Food, Drug, and Cosmetic Act which states that the food plant shall be free from conditions which may result in the contamination of

foods, i.e., dusty roads and parking lots, inadequate drainage, improperly stored equipment, litter, waste, refuse, and uncut weeds or grass in the immediate vicinity of the plant (25). Peterson (27) would also include here the water quality for processing and cleanup.

Equipment Sanitation

Equipment sanitation is extremely important in preventing and controlling microbial contamination of ingredients and products. Also involved is the prevention of contamination of foods with foreign materials (Peterson, 27). This can be attained by using proper chemicals, satisfactory equipment, effective procedures and adequate supervision (23). Furthermore, the entire concept of "dynamic sanitation" requires continuous and total involvement of management and plant personnel with adequate supervision (24).

Employee Personal Hygiene

Employee personal hygiene, including dress, grooming, and good food handling practices, is important in preventing and controlling the inoculation of food materials with pathogens, general microbial contamination and contamination with foreign materials (Peterson, 27). This can be achieved by constant education, by maintaining a pleasant environment within the plant, and by developing a positive attitude within the plant personnel (24).

Microbiological Population Critical Controls

The microbial population critical controls are used on ingredients, materials in process, and products. They help to determine whether the material analyzed conforms to hazard limitations and whether a particular process or processing sequence is being controlled within predefined limits. This testing is the feedback system for HACCP. However, for the in-process or end-products it is only an indicator of whether or not problems have been encountered (27).

Part of the microbial critical controls is microbial growth. Peterson (27) indicates that microbial growth is limited by a time-temperature relationship among other factors. The three factors of time, temperature, and cleanliness are involved in retarding the undesirable biochemical and microbiological changes that take place in the flesh of marine animals during handling/processing operations. The fishery products must be handled and processed as rapidly as possible, from the time they are taken out of the water until they are packed and preserved. A maximum temperature of 40°F (4.5°C) is recommended during handling until final freezing or preservation is accomplished (Pedraja, 25). This is done to minimize the growth of any bacteria already present.

After all of this has been inventoried and evaluated, the next step is to eliminate, on a priority basis, those hazards which are totally correctable (3). According to

Peterson, two of the critical control points here are facility sanitation and maintenance (26). Or, as stated by Pedraja (25), good housekeeping is achieved by maintaining an orderly and well organized system which will prevent or minimize spillage, accumulation of obsolete materials and equipment, disarray of supplies, utensils, machinery, pests, harborage, and the like.

The remaining step is to establish and institute a system of controls for any hazardous conditions which must remain a part of the process (Bauman, 3). Pedraja (26) restates in detail that those in the fish and seafood industry must be constantly alert to the factors affecting the wholesomeness of the products that are processed, handled, procured, or sold. Only by taking the necessary preventive measures and undertaking a dynamic sanitation program can the possibilities of regulatory action be avoided or reduced.

The Need for HACCP

Summaries prepared by the Center for Disease Control show that 1,703 outbreaks of food-borne disease (97,590 cases) were reported by state health departments and other sources during the five years 1968 through 1972 (U.S. Department of Health, Education, and Welfare, 37). The same source (37) states that staphylococcal intoxication, Salmonellosis, and Clostridium perfringens gastroenteritis were the diseases most frequently reported. Furthermore, Bryan (5) states that these figures only represent a small fraction of

the actual illnesses that are related to the actual ingestion of contaminated food, because the public seldom makes official complaints of diarrheal illnesses, and many investigators do not associate such complaints with foods nor do they report all of the outbreaks they investigate. Bryan (5) states that throughout the years since the beginning of reporting of food-borne diseases there has been no indication of a decrease of the food-borne disease problem in the United States. Of 1,615 outbreaks studied in regard to where the food was mishandled, only 104 (6%) were attributed to foods which were mishandled in food processing plants.

Wodicka (41) points out the state of the microbial hazard by listing it first in his realistic appraisal of food safety hazards. Hall (10) claims that this ranking is amply supported by the available evidence. Hall's work comparing the ranking of food safety hazards by regulatory activity, administrative activity, press comment, industry effort, Congressional interest, and fringe hysteria shows that the only category which considered microbiological hazard to be the first priority was the industrial effort.

Why is the situation this way? Part of the answer is that one instance of mishandling can subject hundreds of people to risk (Bryan, 5). The other part of the answer, as illustrated by Hall (10), is the very complex set of interrelationships between the various interests listed above. These relationships tend to cloud the issue of food safety because of conflicting priorities of the various groups

active in the field of food safety.

Sources of Microbiological Hazards

Bryan (5) points out that there are four types (sources) of microbial problems in processing plants: (1) incoming raw foods may be contaminated; (2) processes designed to kill pathogens may fail, and thus permit pathogens in foods to survive; (3) foods may become contaminated during operations after heat processing; and (4) environmental conditions may permit bacteria to multiply to such an extent that they attain numbers (or if toxigenic, produce enough toxin) sufficient to exceed a consumer's resistance threshold and cause disease.

Owing to the nature of frozen raw breaded shrimp, factors 2 and 3 are not applicable, because there are no freezing processes designed to kill the pathogens and there is no heat processing involved in the production of raw breaded shrimp. The microbiological hazards either are present in the raw product, or become a part of the product during its processing.

Animals are often infected with organisms that can cause food-borne disease in man. Some of these organisms are found in the animal's digestive tract and some inhabit its nasal passages. Others may infect cutaneous lesions, or be present on skin, feet, hair, or feathers. They are easily transferred to meat surfaces during processing (5). Some of the organisms involved are *Salmonellae*, *Clostridium*

perfringens, Staphylococcus aureus (Bryan, 5). Vibrio parahaemolyticus is often isolated from salt water fish, shellfish, and crustaceans (Sakazaki, 32). Clostridium botulinum may be found on fish from the mud in lake bottoms (Sakaguchi, 31). Enteric bacteria, viruses, protozoa, and helminthic eggs can be carried to foods by sewage-contaminated water (Bryan, 5).

The problem with raw materials and their contamination varies. Here the problem is simple, raw materials will vary, and biological materials will vary from black to white (Hubbard, 12). Pedraja (23) summarizes this entire problem in his statement on Quality Protection of Marine Commodities. The biochemical changes affecting the composition of marine products can be influenced by a number of factors along the commercial cycle of the commodity. The integrity and quality of the product must be protected at every stage of the commercial cycle. Measures taken are as follows:

- (1) proper handling at the boat level, (2) proper icing and chilling, (3) proper handling and processing by primary producers, (4) adequate reprocessing and packing, (5) fast freezing, (6) suitable freezer storage, (7) proper freezer transport to market, (8) careful handling and rotation of merchandise at the store level, and (9) proper handling and preparation procedures by the ultimate consumer. All possible attention should be given by the industry to the first three factors listed above, for once the product is delivered to the plant for further processing, very little can be

done to undo earlier damage from improper handling on the boat and at the level of the primary producer. The only alternative that we have then is to reject the product. The financial risk and implications of producing unacceptable merchandise must be carefully considered by the primary producer (Pedraja, 23).

Bacterial Multiplication

As stated earlier, a breakdown in production can lead to the development (growth) of a microbial population. Bacterial growth occurs when the temperature, water activity, and other factors of the food and environment permit bacterial multiplication. If conditions are near optimum, the lag period and generation time are short, and large numbers of bacteria develop in a few hours. When foods are held at room temperature, or stored in stock pots, carts or containers, they cool slowly, and near-optimum growing conditions may prevail for a long period of time. If processing operations are prolonged, the bacterial lag phase may pass; multiplication then ensues (Bryan, 5).

What does this mean? Interpretation of data accumulated during epidemiological investigations discloses operations in food processing plants that permit contamination, allow pathogens to survive, and promote bacterial growth. The cause and effect relationship between these inadequate operational procedures and outbreaks of food-borne disease is apparent and provides a basis for officials of industry

and regulatory agencies to recognize food-borne disease hazards that are associated with various operations, to specify critical control points, to train staff and inform consumers, and in general to make better decisions about activities that prevent food-borne disease (Bryan, 5).

While the information on food-borne disease outbreaks attributable to frozen raw breaded shrimp is scarce, there is some information available on the general microbiology of shrimp. Surkiewicz et al. (31) obtained the following results in their survey of the microbiology of frozen raw breaded shrimp in 1966 in plants which they considered to be operating under both good and bad sanitary conditions. The results from plants with bad sanitation were: 69.2% of the samples had aerobic plate counts greater than 1 million organisms per gram; 76.0% of the samples had total coliform greater than 100 organisms per gram; 30.7% of the samples had fecal coliform counts greater than 3.6 organisms per gram; and 51.7% of the samples had coagulase positive *Staphylococcus* counts greater than 100 organisms per gram. The total number of samples was 861. The results of those plants with good sanitation were: 18.9% of the samples had aerobic plate counts greater than 1 million organisms per gram; 58.9% of the samples had total coliform counts greater than 100 organisms per gram; 8.0% of the samples had fecal coliform counts greater than 3.6 organisms per gram; and 3.1% had coagulase positive *Staphylococcus* counts greater than 100 organisms per gram. The total number of samples was 297. The

reduction in the microbial population was attributed to the improved sanitation (Surkiewicz, 33). The difference as percent decrease is as follows: aerobic plate count, 72.7%; total coliforms, 22.5%; fecal coliforms, 73.9%; coagulase positive *Staphylococcus*, 16.6%.

These comparisons are based on: (1) the Food and Drug Administration microbiological guidelines for frozen raw breaded shrimp (Grodner and Novak, 8), and (2) the percent decrease as calculated by $A-B/A \times 100$ where A is the value for good and bad sanitation, and B is the value for good sanitation.

These figures and those from the National Shrimp Breeders and Processors Association indicate that good sanitation is effective (20). As the following results show, there is still need for either more improvement or more realistic guidelines as is shown by the comparison of the Surkiewicz and National Shrimp Breeders surveys. The aerobic plate counts showed 5.94×10^6 organisms per gram for Surkiewicz, and 1.62×10^6 organisms per gram for the NSPBA or a decrease by a factor of 3.67. The total coliforms showed 394.29 organisms per gram for Surkiewicz, and 420.69 organisms per gram for the NSPBA or an increase by a factor of 1.07. The fecal coliform showed 1.09 organisms per gram for Surkiewicz, and 0.71 organisms per gram for the NSPBA or a decrease by a factor of 1.54. The coagulase positive *Staphylococcus* showed 10,611 organisms per gram for Surkiewicz, and 1.03 organisms per gram for the NSPBA or a decrease

by a factor of 10,302.

Obviously, improvement in sanitation is needed because sanitary conditions in firms that process breaded shrimp were reflected in the bacterial content of the finished product. In general, breaded shrimp collected in plants which mishandled shrimp and liquid batter and which were lax in cleaning of equipment contained higher levels of microorganisms than breaded shrimp collected in plants which maintained a good program of sanitation (34). When this is applied to the National Shrimp Breaders and Processors Survey, the results are that the majority of the plants need to improve their operations in terms of controlling the microbiological quality of their product. There is no information available on the sanitary conditions in the plants that participated in the National Shrimp Breaders and Processors study. However, the preceding data does indicate the need for improved sanitation in these plants.

The following were among the poor sanitation practices cited by Surkiewicz et al. (33). They pointed out at length the difference in practices between the good and poor sanitation in the plants they studied. Examples of the poor sanitation are given in the preceding paragraph. Of the 21 plants in the study by Surkiewicz et al. (34), 8 or 38% received a good rating on sanitation. The equipment was cleaned thoroughly before being used and also at least once during the work period. The shrimp were thawed for only a few hours in flowing cold water and were washed in flowing

water before and after peeling-deveining. They were handled expeditiously. The batter was kept cold, and discarded during each cleanup period, and the employees used the hand washing and hand sanitizing facilities made available to them in the processing areas.

Even in these firms, however, there was room for improvement in the thoroughness of washing shrimp and in the frequency of hand washing and hand sanitizing (Surkiewicz et al., 34).

The Basic Nature of the Product and Why It Is Susceptible to Microbial Contamination

Fish and shellfish are highly perishable commodities that decompose rapidly if improperly handled and refrigerated (Novak, 21). The spoilage begins immediately after the fish are removed from the water and under these circumstances handling, cleaning, and processing usually done ashore cannot contribute to the retention of the quality of the product unless it is received from the boats in a fresh state. In the shrimp industry, an unreasonable amount of raw material may become inferior through mishandling between the time of catch and transportation to the processor. The quality of the shrimp when removed from the water, the method of sorting and washing, and proper refrigeration soon after catching are contributory factors for evaluating their quality when the product arrives at the plant. Negligence in the handling of the raw material will completely defeat

any efforts to produce a safe, wholesome food in the processing plant.

It is important that every individual connected with the processing industry realizes that even after the animal is caught and death occurs, very complex biochemical reactions continue to take place in the flesh of the shrimp (Pedraja, 23). These changes are a result of: (1) shrimp muscle enzymes; (2) direct microbiological activity; (3) bacterial enzymes; (4) combination of 1, 2, and 3; and (5) interaction of substances formed by 1, 2, 3, and 4. In a sense the flesh of shrimp after death is still very much active and biochemically alive, and it must be treated necessarily as such. The above listed factors are the ones which define the basic nature of the product. The autolyzing enzymes will bring about an enhancement of the activity of the bacterial enzymes, inasmuch as the bacterial enzymes are not capable of attacking native protein (Pedraja, 23). Intact protein molecules do not readily pass into the bacterial cell and must be hydrolyzed to smaller units by extracellular enzymes before they can be used as nitrogen sources (Burrows, 6). Relatively few bacteria possess extracellular proteolytic enzymes (Rogers, 29). Proteolytic enzymes present in the shrimp muscle play an important role in spoilage by degrading muscle proteins and polypeptides and forming amino acids which enrich the natural substrate and are thus available for the growth of important microorganisms. Handling of the shrimp on the boats results in mechanical damage

to the muscle, which will help bacteria to invade faster. The expressible fluid with its protein and amino acid content will serve as an excellent medium for the growth and reproduction of invading bacteria.

Pedraja (23) states that their deterioration can be retarded by proper handling, icing, chilling, and freezing throughout the life of the product.

Novak (21) summarizes the situation in saying that the fishermen have a product remarkably free of bacteria as it comes from the sea, but keeping it that way requires rapid and careful handling and washing while the product is on the deck, after which proper refrigeration should be used.

There are two other ingredients in breaded shrimp which should also be considered here. They are the batter and the breading.

Breaded shrimp requires only three ingredients: shrimp, liquid batter, and breading. Two of these ingredients, the shrimp and the batter, are excellent substrates for bacterial multiplication (Olson, 22). The shrimp-bacteria relationship was discussed above. When Surkiewicz et al. (34) gave their attention to the batter in their survey, they obtained the following results: (1) the dry powder had low bacteria counts in all categories except total coliform; (2) the use of refrigeration and batter changes kept the bacterial counts low; (3) when refrigeration and batter changes were not used, the bacterial counts went up

by factors as large as 16; (4) properly handled batters show an aerobic plate count increase by a factor of 5 to 8, total coliforms no increase, fecal coliforms increased by 5%, and coagulase positive *Staphylococcus* increased by a factor of 1.25; and (5) improperly handled batters showed an aerobic plate count increase by a factor of 16 to 1,000, total coliform no increase, fecal coliform increased by 38.4% and coagulase positive *Staphylococcus* increased by a factor of 3. This data confirm that the batter is a good growth medium for bacteria. The batter supplements the medium for growth provided by the shrimp, and should possibly add to the bacterial load already present.

The breeding is only a problem when (1) moisture accumulates in the breeding, making it a satisfactory medium for bacterial growth, and (2) the breeding itself becomes heavily contaminated by contact with contaminated batter and shrimp (Surkiewicz et al., 34).

The Pathogenic Bacteria

A pathogen is defined simply as an organism capable of causing a disease, and such an organism will ordinarily be able to produce that disease if present in sufficient numbers (Guthrie, 9). The organisms of concern here are the food-poisoning bacteria. Food-poisoning implies a disease resulting directly from the consumption of food and after a relatively short incubation period (Thatcher and Clark, 35). The food-poisoning bacteria may be classified as follows:

(1) those such as Salmonella and Shigella which multiply in the intestinal tract and cause disease through infection of the host; (2) organisms such as Staphylococcus and Clostridium botulinum whose pre-formed toxins present in the food at the time of consumption are the direct cause of illness; and (3) the third group of food-poisoning organisms for which the precise cause of illness is not yet known such as Clostridium perfringens, Bacillus cereus, and the enterococci.

The infective food-poisoning bacteria are as follows: Salmonellae, Shigellae, enteropathic Escherichia coli, and Vibrio parahaemolyticus. The enterotoxic food-borne pathogens are: Staphylococcus aureus and Clostridium botulinum. Those of an uncertain mode of action are: Clostridium perfringens, Bacillus cereus and the enterococci (Thatcher and Clark, 35).

Before stating which ones are important to the frozen raw breaded shrimp industry, a brief characterization of each would be in order. The last item under the description of each organism will tell why it is or is not important to the breaded shrimp industry. The following information is drawn from Microorganisms in Foods by Thatcher and Clark (35), Textbook of Microbiology by Burrows (6), Zinsser Microbiology by Joklik and Smith (13), and Toxicants Occurring Naturally in Foods by the National Academy of Sciences (19).

The Salmonellae

The Salmonellae are motile, gram negative rods. They are aerobic and growth occurs at a pH of 6 to 8 and temperatures of 15° to 41°C. The Salmonellae are widely distributed in nature. Water and food may be contaminated by humans and animals. Foods prepared without sufficient heating and contaminated water are both very important means of transmission to man.

Salmonella infections follow one of three patterns: (1) typhoid fever, (2) paratyphoid fever, and (3) gastroenteritis.

Typhoid fever is characterized by frontal headache, lack of appetite, nose bleeds, the development of rose spots on the abdomen, muscular weakness, and diarrhea. Paratyphoid fever is much the same, but milder and begins with the sudden onset of chills.

The gastroenteritis is characterized by a short incubation period of as little as 12 hours, acute vomiting and diarrhea with a slight rise in temperature and rapid recovery.

The importance of the Salmonellae to the breaded shrimp industry comes from the transmission of the organism by man and animals, and the fact that shellfish, particularly those from polluted waters, may be contaminated with this organism.

The Shigellae

The Shigellae are short, gram negative rods. They grow at a pH of 6.4 to 7.8 over a temperature range of 10° to 40°C. These organisms are more delicate than the Salmonellae.

The Shigellae are transmitted by humans, flies, contaminated water, milk, and food. Shigellosis or dysentery varies in the intensity of the symptoms which range from mild abdominal pain with only a few loose stools to nausea, vomiting and severe prostration. In the extreme, the discharge is composed of pus, mucus threads, and blood with agonizing colicky pains and constant tenesmus. The incubation time is about 48 hours.

The mode of transmission and the possibility of contaminated raw product is again of importance to the breaded shrimp industry.

Enteropathic E. coli

Escherichia coli is a short, plump, gram negative rod which grow in the temperature range from 20° to 45°C.

Transmission is by either short-term carriers or contaminated food and water. Enteropathic E. coli infection is characterized by a 7-12 hour incubation period followed by diarrhea, abdominal pain, headache and vomiting. The infection lasts for only a short period of time.

Enteropathic E. coli is considered to be a food-borne health hazard only to the very young, elderly, and infirm.

For this reason it is not considered to be of importance to the breaded shrimp industry.

Vibrio parahaemolyticus

Vibrio parahaemolyticus is a pleomorphic straight to slightly curved, gram negative rod. It is also a facultative anaerobic halophile which grows well in the pH range of 5.0 to 9.6 and at a temperature of 37°C.

Transmission is accomplished by consumption of marine fishery products which have not been cooked thoroughly enough to kill the organism.

The symptoms appear after a 6-24 hour incubation period. They start with violent epigastric pain followed by nausea, vomiting, and diarrhea. Fever up to 102°F is observed. Blood and mucus are observed in the feces of severe cases. Death has been attributed to this organism in the Orient.

Its occurrence in marine waters and fishery products makes this organism a very real potential health hazard in all seafoods, including frozen raw breaded shrimp.

The Staphylococci

Specifically, the organism in question is Staphylococcus aureus, a small, gram positive sphere which grows at a temperature of 15° to 40°C and prefers a pH of 7.4.

The modes of transmission are: infected bulk food products, infected people (a nasal carrier or a person with

an open abscess who prepares food), dirty food implements, and those foods which have been permitted sufficient time for enterotoxin production. The enterotoxin is relatively heat stable and is not destroyed by pasteurization.

Staphylococcal food-poisoning is indicated after an incubation time of 2 to 6 hours followed by nausea, vomiting, diarrhea, general malaise, and weakness. In more severe cases there may be collapse and other signs of shock.

This organism is of importance to all food processors because of its commonness, the heat stability of the toxin, and the limited techniques available for the detection of the toxin.

Clostridium botulinum

This organism is a large, pleomorphic, motile, sporulating, gram positive rod. This anaerobe grows at 25°C and higher. The spores are very heat resistant, and are able to withstand boiling from 30 minutes to 22 hours, and autoclaving at 120°C for 20 minutes. The toxin produced by this organism is heat labile and one of the most potent of the bacterial toxins. Heat destruction of the toxin requires exposure to a temperature of 80°C for 30 minutes or boiling for 10 minutes. The toxicity is indicated by the minimum lethal dose (MLD) for the guinea pig which may be as small as 1×10^{-6} milliliters of broth culture.

The mode of transmission for humans has been confined to the consumption of (improperly) preserved foods.

The symptoms following a 6 to 24 hour incubation period include paralysis of the striated muscles and diaphragm, vomiting, constipation, ocular paresis, and pharyngeal paralysis.

Due to the nature of the packaging of raw breaded shrimp, Clostridium botulinum would be only a minor hazard. The presence of oxygen during processing and in the packaging serves to inhibit the growth and toxin production of this organism.

Organisms with Uncertain Modes of Action

Clostridium perfringens.--Clostridium perfringens is a short, plump, spore forming, gram positive rod. This organism is also anaerobic. Optimal growth requires the presence of a fermentable carbohydrate.

The transmission of Clostridium perfringens has been accomplished primarily by the consumption of uncured meats and mammalian feces. However, a population of one million cells per gram is needed before any disease is likely to result.

Perfringens food-poisoning is a relatively mild malaise characterized by abdominal pain and diarrhea following ingestion by about 8 to 18 hours.

Again, because of the presence of oxygen during processing and in the pack, Clostridium perfringens cannot be considered a serious health hazard in frozen raw breaded shrimp.

Bacillus cereus.--Bacillus cereus is a large, gram positive, spore-forming, aerobic rod. Little is known about how Bacillus cereus becomes involved in food-poisoning. It is common in soil, on vegetation, and in many raw and processed foods. Inadequate refrigeration of moist, cooked protein foods is an essential factor in the growth of this organism.

The symptoms are very similar to those of Clostridium perfringens. This organism has not yet been implicated as a hazard in seafoods.

The Enterococci.--The Streptococci are small gram variable spheres which usually occur in chains. They grow in the temperature range of 10° to 40°C. Optimal growth occurs in the pH range of 7.4 to 7.6. There are both pathogenic and saprophytic members of this family.

The Streptococci are ubiquitous, that is, fairly common. The pathogenic members of the family are spread by either carriers or persons with active infections.

At the present time, there have been suggestions that these organisms can cause food-borne disease, but this has not yet been substantiated.

The above material indicates that four pathogens are the organisms of major concern in frozen raw breaded shrimp: (1) Salmonella sp., (2) Shigella sp., (3) Vibrio parahaemolyticus, and (4) Staphylococcus aureus.

It is noteworthy and should be emphasized that any

pathogen may gain access to the final product by transferral from a person with either an active case of the disease, a carrier state for the organism, or a residual presence of a pathogen. Such persons should be kept away from the product, raw materials, packing materials, and processing area until they have rid themselves of the organism in question.

Integration of HACCP into Present Quality Control Programs

This is the subject of the remainder of this research. The goal is the control of the four pathogens listed above as presenting the greatest health hazards in frozen raw breaded shrimp. The literature review has presented the basic background about the product and its sensitivity. Bauman (3) states that three things must be done to institute HACCP. These are hazard inventory, hazard elimination where possible, and the establishment of critical control points where the hazard cannot be eliminated. The second and third phases of the institution of HACCP are very highly dependent upon the local plant situations, since these situations are the very hazards themselves. Therefore, the following hazard analysis will be general in nature, and the critical control points that will be set up will serve as guidelines for actual use in the plant.

What has caused all of this to come about? Other than the current status of food-borne disease, there is a considerable body of evidence in the literature calling for

improved quality assurance in the food industry. Some of these refer to the government's participation in quality assurance (Lyng, 16; Wodicka, 41). Majorack (17) considers the government quality assurance programs as a means to achieve compliance, while Skinner (33), Lawler (15), and Roberts (29) enumerate the benefits to government, industry, and the consumer. HACCP, the systematic approach for improved quality by more control over the raw material, its processing, and the handling of the final product, is an important way the government is participating in quality assurance.

Chapter 2

EXPERIMENTAL IMPLEMENTATION OF HACCP

This chapter will describe the methods used in the implementation of the Hazard Analysis Critical Control Points concept. There are basically two parts to HACCP: (1) the analysis and evaluation for the hazardous conditions and practices, and (2) the establishment and operational application of the critical control points.

Hazard Analysis

All of the following procedures are currently in use by the industry today. Treating the plant, the process and the equipment all as one system constitutes the major change when implementing HACCP. Part of the concept, as applied, is the use of the records that the company keeps. When this is applied to the records from quality control and sanitation, there is then a guide for where hazardous conditions may exist.

The Food and Drug Administration (FDA) has set up a special program to train their inspectors in the application of HACCP. Those not eligible for the FDA training program may take formal training in a university or training by on-the-job experience. Preferably, the on-the-job training

will be in quality assurance and sanitation. All the methods there are those utilized by the author during two and one-half years of work in the breaded shrimp industry.

The inventory of hazards is greatly eased when those responsible for the inventory are experienced enough to effectively analyze those conditions which may be hazardous. Some of the problems are specifically pointed out in the Good Manufacturing Practices found in parts 128 and 128A of Title 21 Code of Federal Regulations (39). The remainder of what to look for comes from education or experience or both. The term "look" is very applicable, as the analysis for hazards is accomplished mainly by observation and the records of those observations. Observations can be and are made by any number of methods in addition to visual observation.

There are several methods used for the hazard analysis. The first step is to break down the process, plant and equipment into several sub-processes. This can be done by basing the sub-process on an operation or series of very similar operations, or operations that occur immediately one after the other. This is the basis for each of the remaining chapters with the exception of the last chapter. This subdividing has been applied to the general flow diagram (Diagram 1) with the flow diagram for a particular operation accompanying the chapter on that operation.

The methods used to observe the hazards are visual, olfactory, tactual, and microbiological. The visual method

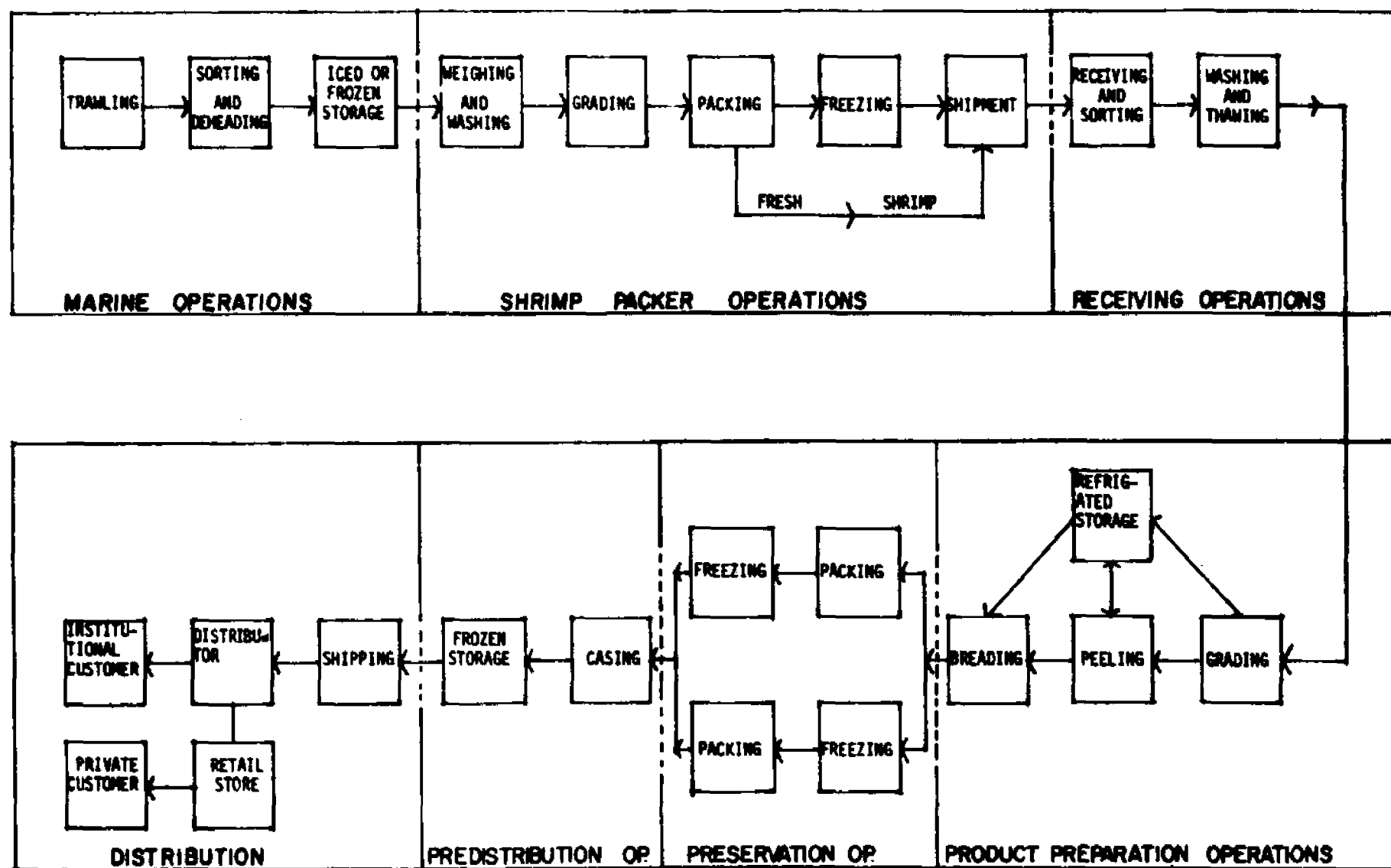


DIAGRAM 1

FLOW DIAGRAM FOR FROZEN RAW BREADED SHRIMP
SUBDIVIDED INTO SUBPROCESSES FOR HAZARD ANALYSIS

is probably the most extensively used and the most frequently abused means of inspection. The requirements are relatively simple: i.e., fairly good eyesight, knowledge of that for which one is looking, a supplementary light source, and an ultraviolet light source. Visual inspection is used to evaluate the effectiveness of sanitation and cleaning, plant construction and maintenance, process flow and product handling and personnel sanitation.

When the sanitation is being checked, the following are some of the actual items which are checked: accumulation of shrimp parts and particles in and on thaw tanks, wire mesh belts, peeling machines, tubs, pans, carts, scale pans, etc.; batter residue in pumps, hoses, troughs, batter machines, batter tanks, etc.; the formation of scale or milkstone on all batter equipment; breaching particles on and under the packing belts, breaching machines and switch boxes (inside and out), drop cords and water lines, etc.; the accumulation of trash and debris around the walls, and on the floors, around and on box formers, on and around the packing belts and box sealers/wrapping machines.

The plant construction and maintenance are fairly easy to check. Some of the items of concern are: cracks and crevices in and between the walls, floors, and ceilings; defective plumbing; areas where condensate can form and fall into the product; housekeeping in the shop areas; ice making, storage, and distribution system for any means of contamination such as condensate, moisture from the floor, and

contaminated ice handling equipment, etc.

Inspection of process flow and handling used the same method of observation, but some supplemental equipment is recommended. The watch and tags are used to check the processing times, while the thermometer is used for checking temperatures. Pocket and long-stem thermometers are both useful; both should have metal stems. Other than times and temperatures, some of the items to watch for are the handling of drops and spills, and the handling of batter, bread-ing and the finished product.

Personnel sanitation can be checked by looking for clean uniforms; clean, well manicured, but not polished, fingernails; and appropriate hair control. Personnel should be free of cuts and abscesses and should practice good personal hygiene.

The olfactory inspection is primarily used in two areas. The first is in the detection of any odors indicating a build-up of shrimp material on the wire mesh belts. The second is the detection of any sour odors in batter equipment indicating that the cleaning did not remove all of the old batter.

The tactual inspection (by sense of feel or touch) is used in those areas which cannot be seen because of the construction of the equipment. This method should be applied with caution, lest there be serious injury. It should never be used while the equipment is in operation.

The microbiological methods fall into two categories.

The first category is for those methods used in sanitation evaluation. The second category is for those methods which are used to evaluate the raw material, the ingredients while being processed, and the finished products.

The microbiological evaluation of sanitation can be accomplished in any number of ways. One method involves the use of sterile screw-cap cotton swabs. The swab is used to pick up any bacteria present on the surface in question. This is done by rubbing the swab directly on the surface. The swab is handled by the plastic screw-cap to which it is attached to minimize any possibility of contamination. The swab is labeled as to the source, then taken to the microbiology laboratory. Once in the laboratory, the swab is streaked on plates of various media, incubated at 35°C for 24 hours, observed, and the results recorded. The media will vary according to the choice of the responsible personnel, and the organisms being sought. Toloday (36) recommends the following media for specific organisms: Aerobic plate count: Eugonagar; coliforms and Escherichia coli: Levine's EMB agar; coagulase positive Staphylococcus: Vogel-Johnson agar; and Salmonella-Shigella: Hectoen Enteric agar. The results are recorded as no growth, slight, moderate, heavy, or excessive growth.

There is an alteration of this method which is in use by Reddy (28). The method is essentially the same, but a template of known area is used during the swabbing, followed by the use of dilution blanks to obtain a count in

terms of numbers per square centimeter. The templates are sterile before the swabbing. The initial dilution is made by stirring the swab in a 9 milliliter dilution blank.

The second group of methods involves the microbiology of the raw materials and the product. Before going into the methods proper, the discussion of sampling is in order. There are two main considerations here:

(1) the sampling of the population, and (2) how the sample is treated. The term population refers to the total number of cases, packages, etc., in the lot or shipment being sampled. The rate of sampling is usually based on statistics but may be altered by such factors as the nature of the product, the treatment of the individual sample, and the past history of the quality of the product from a particular supplier.

When a product is sampled, the sample is placed on dry ice and then transported to the laboratory. If dry ice is not available, the sample is held on ordinary ice, and is either frozen, or analyzed as soon as possible.

From this point, the methodology is as outlined below. The reference procedures are as follows: Aerobic Plate Count: AOAC Standard Methods Specification No. 41.015; Total Coliform and Escherichia coli: AOAC Standard Method Specification No. 41.016; Coagulase positive Staphylococcus aureus: AOAC Standard Method Specification No. 41.018; and Salmonella: AOAC Standard Method Specification No. 41.024 through 41.040 (11).

Additional methods used are the rapid methods developed by Grodner et al. (7) at Louisiana State University under sponsorship of the National Shrimp Breeders and Processors Association, Inc. The methods are unpublished at present but are being edited for publication in the very near future.

There were two supplemental procedures used. The first is for Shigella as given in Chapter 11 of the Bacterial Analytical Manual of the Food and Drug Administration (38). The second method is for Vibrio parahaemolyticus as given in Chapter 14 in the Bacterial Analytical Manual of the Food and Drug Administration (38).

Regardless of how good any methodology might be, it must be accompanied with adequate record keeping, or else little will have been accomplished. The records should be complete, concise, and effectively organized, as well as properly stored, and kept current. The records are used in the evaluation of the effectiveness of the various critical controls. Samples of some record forms will be found in Appendix II.

Once the inventory is completed the next step is the establishment of critical control points. This is done by eliminating those hazards that can be corrected. Then by analyzing the remainder, and the individual characteristics of the plant and its management, the points in the process for the critical controls are identified. Working with management, the controls may then be instituted.

The results are given in summary form in the various tables. Each table is located in the section that deals with the particular hazards listed in that table. Each table is a summary of inspection results obtained from two of the largest shrimp breeding plants in the United States over a period of seven hundred twenty (720) working days. Each table will have a statement as to the number of inspections from which the results are drawn. The results are expressed as the percentage of inspections where the microbial results were equal to or greater than the FDA raw breaded shrimp guidelines. These guidelines are: (1) Coliforms (T.C.)--greater than 1100/g in all subs or (2) E. coli--greater than 3.6/g in 20% of subs or (3) Coagulase Positive Staphylococcus--greater than 3.6/g in more than 50% of subs or (4) Aerobic Plate Count (TPC)--greater than 1×10^6 /g in geometric progression in subs. If Coagulase Positive Staphylococcus are present in quantities greater than 100/g in more than 20% of subs, plus specifiable conditions which are in violation in plant as specified by the code, then action will be taken (Grodner and Novak, 8).

Chapter 3

HAZARD ANALYSIS OF MARINE OPERATIONS

The operations on board the shrimp boat are the beginning of the process of breeding shrimp. The first requirement is catching the shrimp. The method used is seining. The net is closed off at the tail end, and kept open by otter boards, a chain, and floats on the front end. The net is dragged across the floor of the body of water. The shrimp which are resting on the bottom (or in) the sand are disturbed, swim up, and then caught in the net. After a given period of time, the net is hauled up and emptied on the fishing deck, and then returned to the ocean bottom. Figures 1 and 2 show the layout of a shrimp trawler.

Once the shrimp are on the fishing deck, they are sorted; i.e., the trash fish, crabs, etc., are separated from the shrimp. The shrimp may or may not be deheaded on the boat. After deheading, the shrimp are placed in the hold between layers of ice, and are kept iced until they are delivered to onshore customers. The shrimp today are being frozen in large blocks by an increasing number of the boats.

The outline of the occurrence of hazards in their location of occurrence is in the flow diagram (Diagram 2)

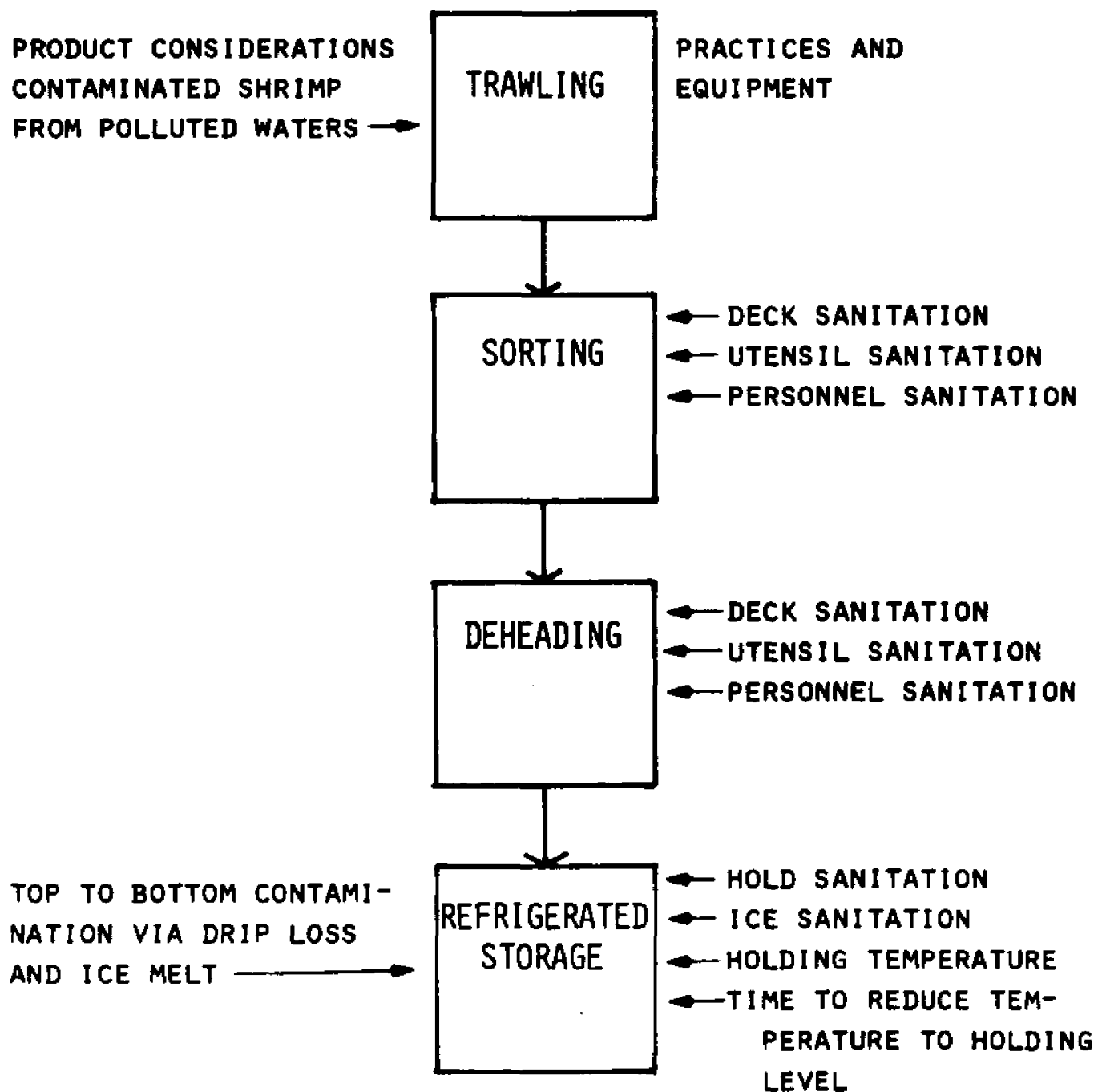


DIAGRAM 2
HAZARDS IN MARINE OPERATION

for marine operations. The microbiological profile of some of these hazards is shown in Table I.

Table I. Shipboard HACCP (120 inspections)

Hazard	Inspections exceeding FDA microbiological guidelines (%)				
	Total plate count	Total coliforms	Fecal coliforms	Coagulase positive Staphylococcus	<u>Salmonella-Shigella</u>
Polluted water	0	29	18	5	5
Fishing deck	26	55	47	88	53
Utensils	47	17	2	95	10
Hold	18	13	2	16	10

The first hazard encountered on the boat is the problem of fishing in polluted waters. The shellfish in polluted waters are frequently found to be contaminated with either pathogens or indicator organisms. Thus these shellfish will in turn contaminate all the surfaces and equipment with which they come into contact.

The critical control for this hazard is the avoidance of known polluted waters. However, this is not always possible. When the shrimp come from polluted waters, they should be washed in a hypochlorite solution of 50 ppm strength before deheading and a similar solution of 10 ppm strength after deheading. This should be followed by either a non-polluted salt water or potable fresh water rinse before refrigeration.

There are several hazards on the fishing deck. The first hazard is the condition of the deck itself. Is the



Figure 1. Shrimp boats in the harbor.

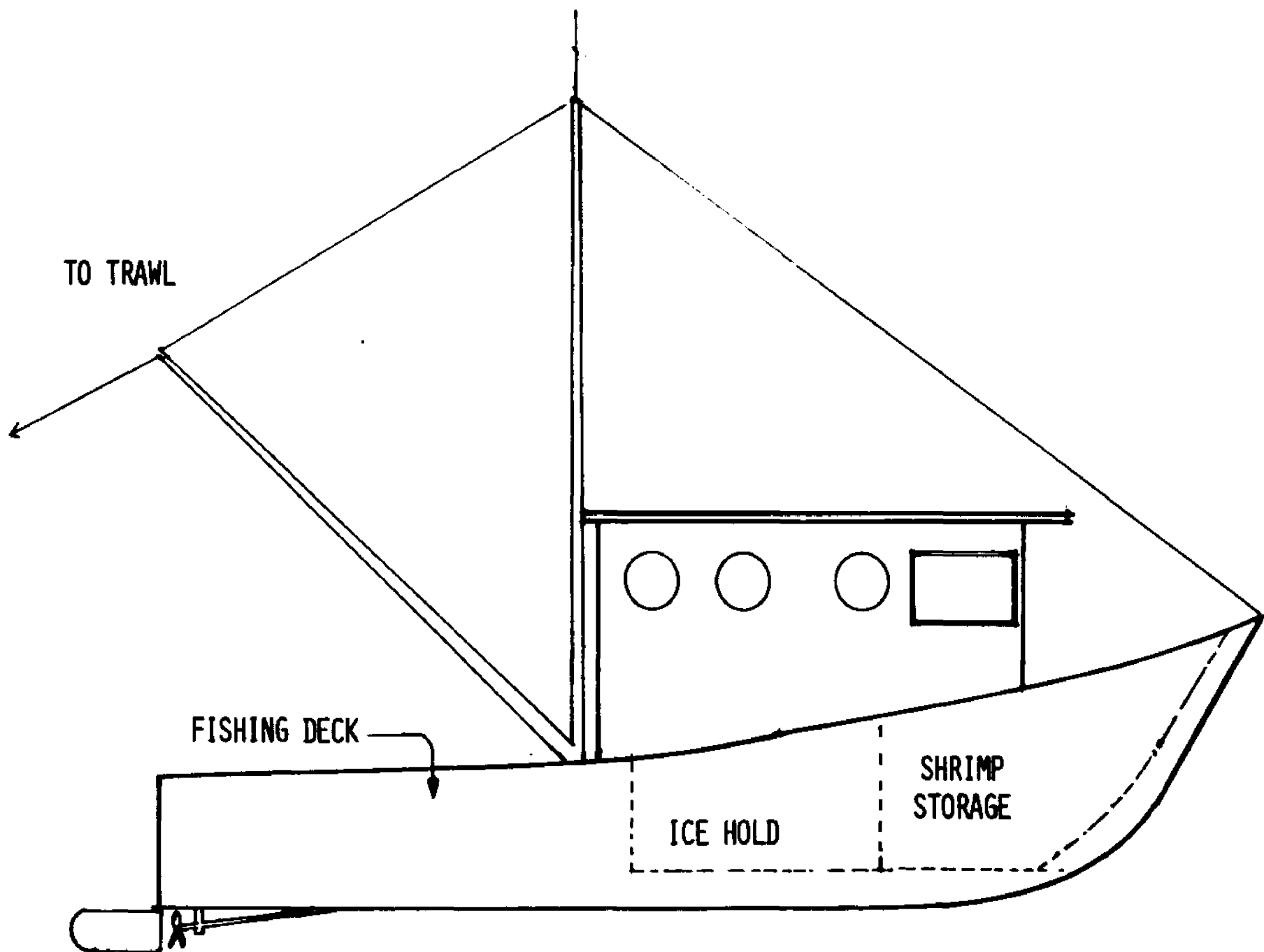


Figure 2. Shrimp trawler.

deck made of steel or is it porous wood? The wood presents a double hazard. The first is the contamination of the product with wood splinters, slivers, paint flakes, etc. The second hazard is microbial contamination. The microbial population has a place to hide and survive in the porous surface. The bacteria found here are dependent upon the treatment on the deck. On some vessels, where the fishing deck is either used as the restroom or is contaminated by carryover on the shoes and boots from other parts of the deck which are used as restroom facilities. This can result in very definite contamination of the product with human waste and pathogens. This hazard is particularly compounded in the absence of deck sanitation. Additional contamination comes from failure to wash the deck between loads of shrimp, allowing the build-up of fluids and slime which promote bacterial growth. Good deck sanitation is the best control. First the wooden deck should be replaced with stainless steel, if possible, to eliminate the hazards mentioned above. This eliminates the problems of foreign material such as wood splinters and slivers. The microbial contamination due to the parasites of the wood is eliminated.

On vessels without proper restroom facilities, a restroom should be installed, if possible. If not, then a special section of the deck, which is well away from the fishing deck, should be reserved for this function. Immediately next to this area should be hand-washing facilities, and a boot or shoe dip of a strong (100 ppm or stronger) chlorine solution.

Use of both facilities must be mandatory for the crew.

The fishing deck itself should be washed down before and after each load of shrimp. The wash should be done with a 10 ppm hypochlorite solution followed by a good quality water rinse following the shrimp washing. The purpose of the rinse is to minimize corrosion of the deck owing to the action of the chlorine and/or the salt water.

The hazards of the utensils are the same as those for the fish deck. The controls are also the same with the addition that the entire utensil, including the handle, should be of either steel or plastic construction, as recommended in the Good Manufacturing Practices (parts 128 and 128E, title 21 of the Code of Federal Regulations, 39).

The area of the refrigerated storage of the shrimp is probably the most critical of those to be analyzed for hazards. Because of the time factor, which may extend from a few days to a month or more, the storage conditions can make or ruin the product. The hazards are not many in number, but they are decisive in the contamination and decomposition of shrimp.

The first hazard is the sanitation of the hold. Has it been contaminated by bird droppings, dirt and debris carried in by shoes, bilge water, or the like? Is the hold made of steel and is it well insulated? Has drainage been provided for the runoff from the melting ice? If the hold is not in acceptable condition, then it becomes contributory to the decomposition of the shrimp by serving as a

reserve supply of bacteria for contamination. The best critical control here is to have the hold made of a durable material, such as stainless steel, with mechanical refrigeration for temperature maintenance. The hold should be cleaned before use. The hold should have a procedure for draining, and should be sealed off in such a manner that gases and liquids from the bilge may not enter the hold. The critical control here is to keep the hold clean.

The ice, which is used either as a supplement to, or instead of, mechanical refrigeration has three particular hazards attached to its use. The first hazard is contamination of the shrimp by the use of ice made from contaminated water. As the ice melts, its bacterial content is released into the dripping water, to reach and contaminate the shrimp. The second hazard is the transfer of bacteria picked up by the ice from contaminated surroundings such as dirty ice holds, dirty ice utensils, and personnel walking in ice bins. The third hazard is the conductivity of dripping water from melting ice. The conductivity will carry the bacteria from the upper layers of ice and shrimp to the lower layers of ice and shrimp resulting in substantial increases in the microbial population of the lower layers of shrimp.

All the problems of the ice can be eliminated completely by going to a mechanical freezing system. The shrimp are frozen in ice (glazed) by use of the freezing system and water, and are protected both by temperature and,

to some degree, with a physical cover. However, not all boats have, or can convert to, the mechanical freezing system. Therefore, to minimize the hazards related to ice, ice should be: (1) bought from sources which use potable water for making ice; (2) all ice storage areas and equipment should be thoroughly cleaned and sanitized before, during and after use; and (3) the maintenance of as low a temperature as possible in the hold where stacking in boxes and drainage will minimize the top to bottom contamination of shrimp in the hold.

The final in-the-hold hazard actually begins when the net is pulled out of the water. The hazard here is the length of time of exposure to warm temperatures, including the elapsed time from ambient temperature to cold storage temperature. The time factor determines how far the breakdown reactions can proceed, and how much bacterial growth has occurred. These in turn determine the quality of the product, the rest of the way through processing to distribution. A bad start produces a product which is much more sensitive to handling and has a shorter commercial life.

The control procedure here is to sort, dehead, rinse, store, and ice or freeze the shrimp as quickly as possible. Expeditious handling without the use of sufficient ice to bring about a quick chill is wasted energy. The ice and the shrimp should be well mixed to achieve maximum cooling. The freezing will then depend upon the equipment and process



Figure 3. Proper handling of crushed ice.

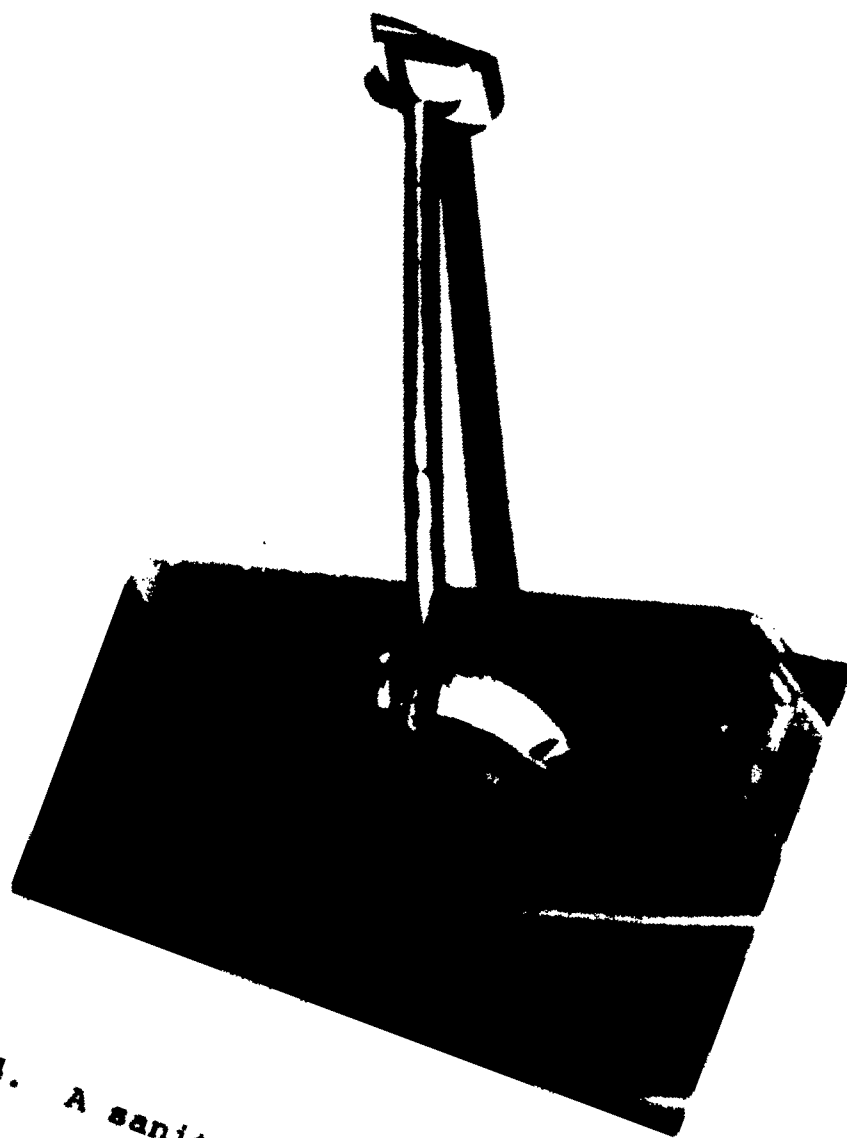


Figure 4. A sanitizing dip for ice shovel.

used. However, if they are to be frozen, then the freezer temperature should be around -40°F if at all possible.

Chapter 4

HAZARDS ASSOCIATED WITH SHRIMP PACKING

Before the shrimp reach the processor, there are two steps through which they must pass. The first is the shrimp packer and the second is transportation from packer to processor. This second step will be discussed in the next chapter.

The term "packer" as used here refers to those companies and individuals who, after buying the shrimp from the boats, wash, dehead (if needed), grade, freeze (if applicable) for sale as either fresh or frozen green headless shrimp. The shrimp packer is the second major operator to handle the product. The hazards are located by Diagram 3 and their microbiology is given in Table II.

Table II. Shrimp Packer HACCP (120 inspections)

Hazard	Inspections exceeding FDA microbiological guidelines (%)				
	Total plate count	Total coliforms	Fecal coliforms	Coagulase positive Staphylococcus	<u>Salmonella-Shigella</u>
Wash tanks	27	12	16	74	10
Wooden crates	86	77	14	83	5
Ice	15	7	4	12	2

PRODUCT CONSIDERATION

SANITATION

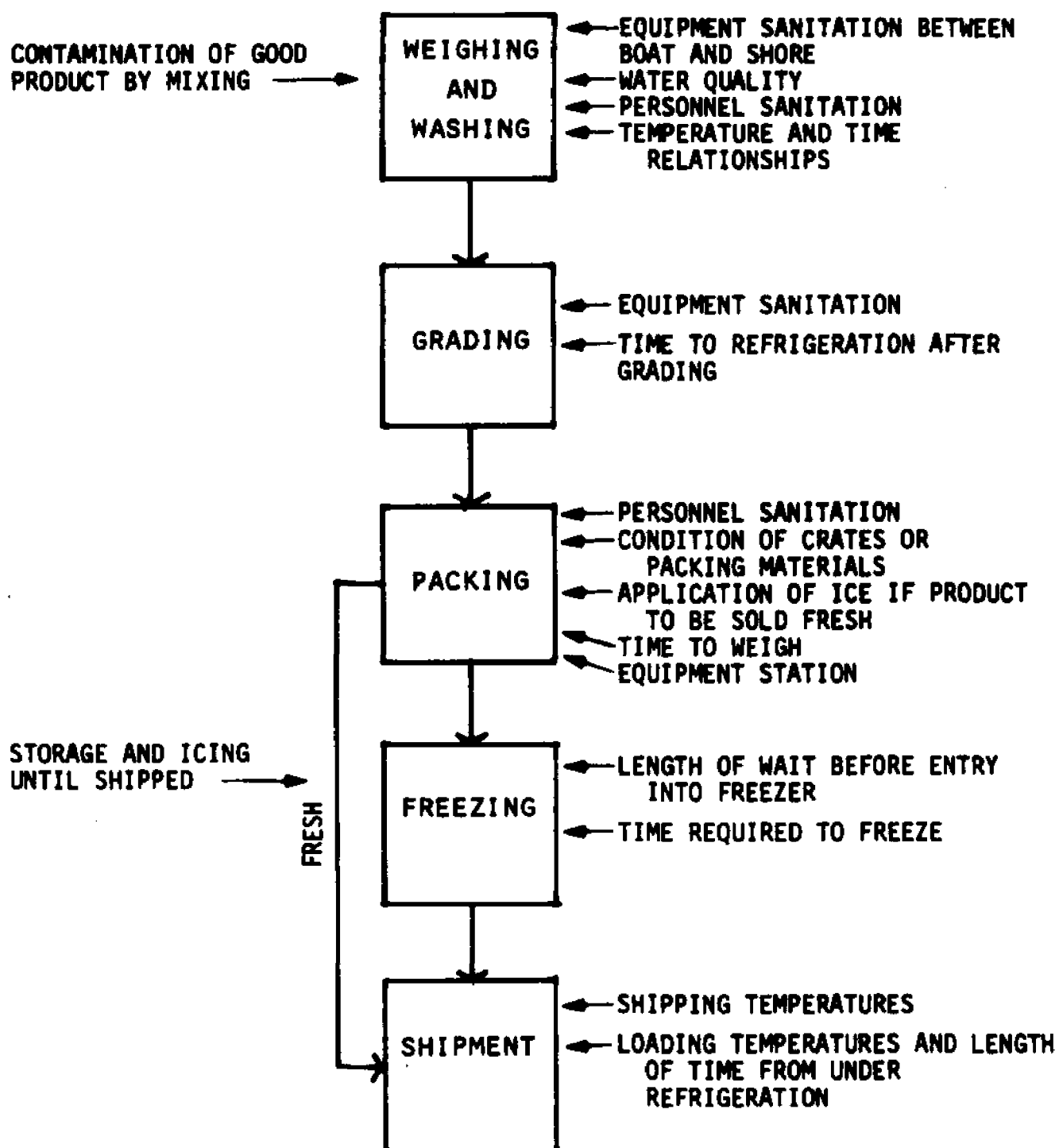


DIAGRAM 3

HAZARD ANALYSIS AT PRIMARY PACKER

The first hazard to be encountered is the sanitation of the equipment between the boat and the shore. The degree of the hazards is dependent upon the system used to unload the boats. If a metal basket with block and tackle is used, then the basket should be clean, i.e., no shrimp parts, shrimp juice, etc., on the basket. There should not be any rust or corrosion. If a conveyor system is used, then the belt top and bottom should be clean and free of debris. The bottom side of the belt, the drive shaft and idler shaft, are very sensitive areas, as the shrimp, shrimp parts and shrimp juice build up there. This accumulation is ideal for the growth of bacteria, including certain pathogens. If a pump system is used, the same problems are encountered with the pump impeller, pump housing, suction and delivery hoses.

The best control here is a good strong sanitation program including the rinsing of equipment between boats. Another equipment hazard is the scale. The hazard here is the same as for the basket method of unloading the boat, and with a good sanitation program it provides not only clean scales, but also more accurate weights.

Water quality is a hazard throughout the entire process. If water quality is poor, water is then a strong liability. Water is an asset if it is high in quality. Water quality and personnel sanitation will be discussed in detail in Chapter 9.

The hazards of time and temperature are more or less the same wherever they occur throughout the process. Since

the product cannot be processed and kept frozen or even well iced at the same time, the best approach is to keep the shrimp iced between processing steps, and chill the product as rapidly as possible between and after processing steps. This requires the generous use of good quality ice and water. The problems of ice have been discussed in Chapter 3.

The wash tank is a modified conveyer system which uses an endless wire or plastic belt and a metal tank. The additional hazard involved here is contamination due to the tank and its accessory equipment.

The contamination can come from the drainage system, the floor, gate and the walls of the tank. Here again, a strong sanitation program and adequate plumbing are the best controls.

The process or flow hazard here is the problem of letting the shrimp remain in the water while waiting for further handling.

The next process is grading, which presents an equipment hazard of its own. The hazards are on the underside of the lift belts, the rollers and dividers, and the chutes. The hazards of the lift belts have been discussed earlier. The rollers and dividers are particularly sensitive to the build-up of slime and shrimp juice. Bacteria can survive and grow on this slime-juice and, therefore, to avoid contamination, frequent and thorough cleaning is needed. The chutes are sensitive to the failure of shrimp to fall all the way through to the baskets or pans. The shrimp which



Figure 5. Shrimp graders after cleaning.

do not fall through decompose quite rapidly and are a definite source of contamination when mixed with the shrimp of good quality.

Associated with the problem of grading are problems dealing with wooden crates, pans, tubs, etc., which are used to catch the shrimp. All the pans and tubs need to be cleaned and sanitized to avoid the hazards of contamination from any residue in them. The wooden boxes (crates) are a hazard in themselves, and are fairly widespread in use throughout the industry. The wooden crate is used for the transportation and holding of the fresh green headless shrimp and the graded fresh green headless shrimp.

The problem of the crates comes from the porosity of the wood and the splintering and breaking of the wood and wire. The porosity of the wood and construction of the crate creates a reservoir for a considerable microbial population. The wood often splinters and breaks, resulting in the foreign contamination of the shrimp with wood slivers and splinters. The best control of this hazard is the elimination of the wooden crates wherever possible. If the crates must be used, the only alternative is their removal as their condition deteriorates, and strong sanitation just prior to use. The sanitation can be accomplished by dipping in a calcium hypochlorite solution of 50 to 100 ppm strength.

The hazard of packing is essentially the problem of rapid handling and chilling. The fresh shrimp are bulk-packed in wooden crates and the problem is to supply enough

ice to the crate to keep the temperature at 40°F or colder. This also applies to the freezing process where the shrimp are packed in paper-board cartons. The problem is to get the shrimp into the freezer as quickly as possible. The best control here is a good conscientious supervisor who will see that the product is expeditiously handled.

Shipping poses one hazard. This hazard is the maintenance of temperature during loading and shipping. The critical controls here are (1) proper supervision to see the product loaded quickly, and (2) education of the carriers as to the urgent need for refrigeration. Transportation and shipping will be covered in greater detail in Chapter 8.

Chapter 5

HAZARDS FROM RECEPTION THROUGH PRODUCT PREPARATION

The hazards in this phase of the shrimp breeding process are very similar to those discussed in the preceding chapters.

From the point of reception to the end of the grading sequence, the hazards are identical to those of the shrimp packer through the completion of the grading sequence. This can be seen in Diagrams 4 and 5. The discussion of this material can be found in Chapter 4. The microbiology of this series of operations is very sensitive, as is shown in Table III.

The next step in the operation, after the grading, is peeling/deveining. There may be an intermediate step where the graded shrimp are placed in refrigerated storage until the peeling department is ready to receive them. The desirable practice of refrigerating the product at all times also has its hazards. The most important hazard is that the product will not be chilled fast enough or all the way through. This can be the result of the failure to use enough ice and/or of putting too many shrimp in one large container. Because of the slow rate of heat transfer, the shrimp in the interior may remain hot for an extended period of time. The

PRODUCT CONSIDERATION

SANITATION

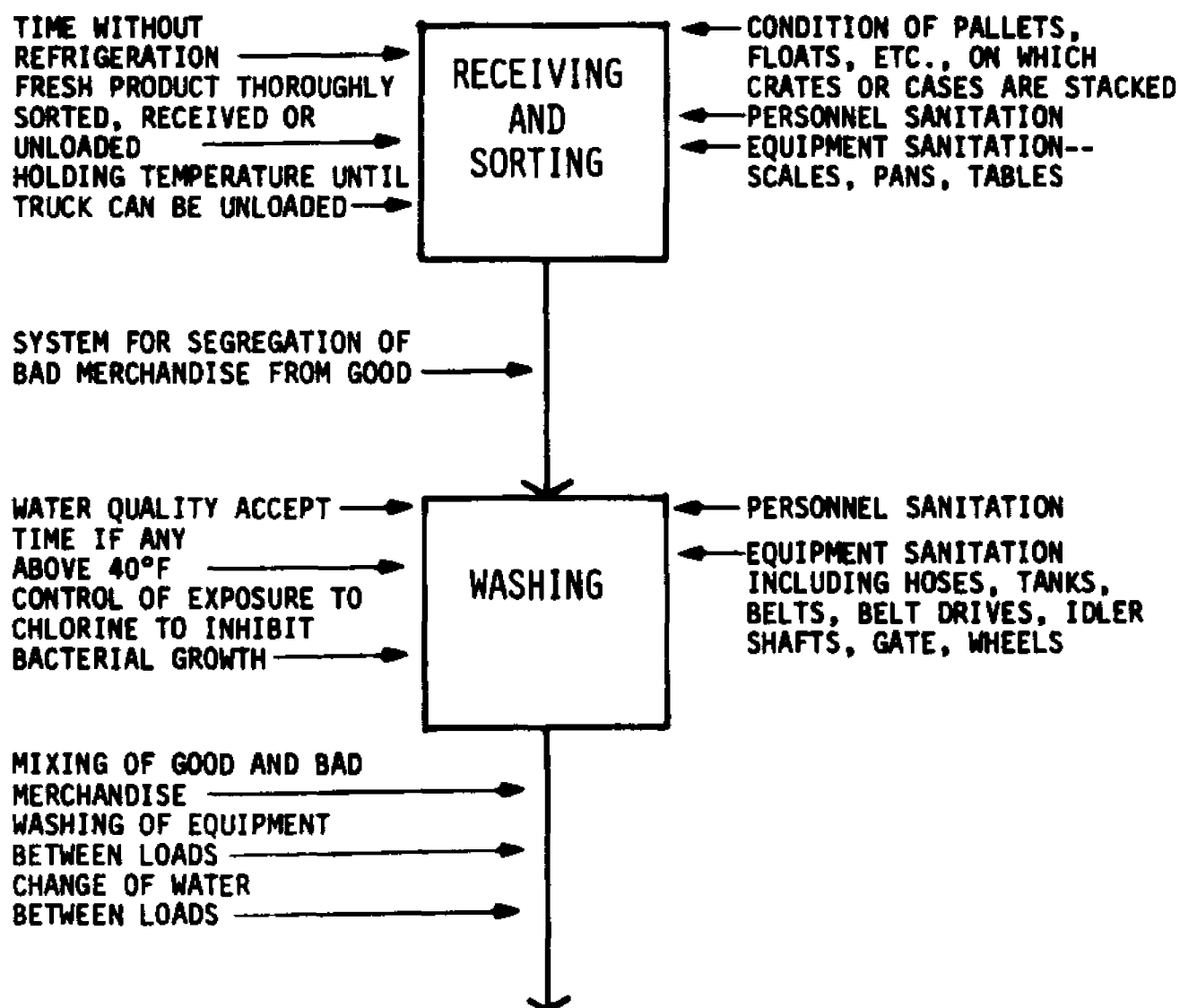


DIAGRAM 4

HAZARD ANALYSIS FOR RECEIVING AND WASHING OPERATIONS

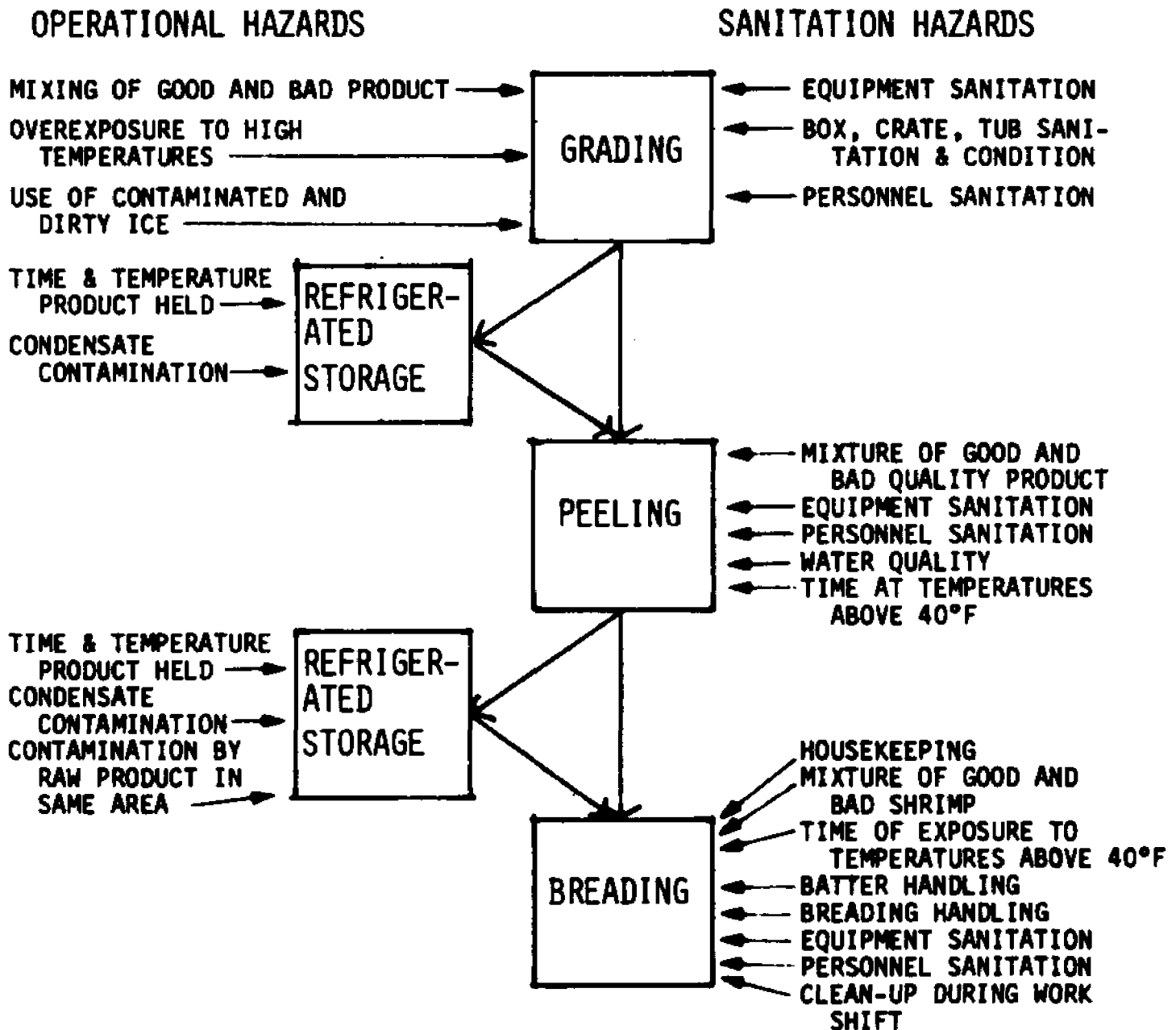


DIAGRAM 5
HAZARD ANALYSIS OF PRODUCT PREPARATION OPERATIONS

best controls of this are a monitor system for products in refrigerated storage and the utilization of much ice.

Table III. Product Preparation HACCP (650 inspections)

Hazards	Inspections exceeding FDA microbiological guidelines (%)				
	Total plate count	Total coliforms	Fecal coliforms	Coagulase positive	<u>Salmonella-Shigella</u>
Raw water	0	0	3	0	rare
Finished water	0	0	0	0	0
Wash tanks	25	14	14	19	5
Graders	48	36	15	11	2
Refrigerated storage	42	12	4	6	rare
12 hours	53	6	1	5	rare
24 hours	71	15	5	6	rare
48 hours	84	21	11	4	rare
Peeling	49	52	38	87	1
Sorting belt	3	3	1	18	2
Batter machine	64	58	42	86	12
Breading machine	5	0	0	5	0
Batter liquid	75	5	2	94	5
Breading	2	1	1	12	0

The second hazard found in refrigerated holding is contamination by condensate. This occurs when the moisture contained in the atmosphere meets the cold air inside the refrigerator, and the moisture condenses on the cold surface, forms droplets of water, and then proceeds to fall from the ceiling or higher level surfaces onto the product stored below. There are two possible solutions to this hazard. First, keep the refrigerator door closed as much as possible to reduce moisture in flow, and second, keep the product covered to protect it from any condensate that

might form. The condensate picks up and brings with it any bacteria and dirt it encounters.

The final hazard of refrigeration is the possibility of aging. That is, the product is set in a corner or neglected for several days. The result is shrimp of poor quality. The refrigeration slows down but does not stop the decomposition of the shrimp. The best control here is the inventory of refrigerated storage and inventory control.

The shrimp then move from the grading and refrigerated storage into peeling. Here there are two equipment hazards and two process hazards.

The equipment hazards come from unsanitary peeling machines and unsanitary accessory facilities, such as troughs and conveyor belts. The peeling machines come in two varieties: Johnson and Pronto. The Pronto is the simplest with two guide wheels and one knife wheel. The Johnson is considerably more complicated as it not only cuts the shrimp but also removes the shell and vein afterward. The shell and vein are removed by hand after the shrimp goes through the Pronto machine. The hazard of the peeling machine is simply ineffective cleaning of the internal mechanism as is indicated by moderate to excessive growth on swabs taken from this equipment. The accessory equipment presents the same problem, except that it is primarily the external surfaces which are not cleaned properly. Again, good sanitation with good monitoring will reduce the hazard.



Figure 6. The peeling and deveining operation process of shrimp for breaded shrimp.

The processing hazards are of two different natures. The first is failure to keep the product iced or chilled enough, thus allowing decomposition and bacterial growth. This occurs before, during, and after peeling. Shrimp coming from the wash tank to peeling may either be on the belt too long or are not iced down during breaks and lunch periods. The shrimp may then be thrown into a 500-gallon tank with no ice. The ice is added only after 300 or 400 pounds of shrimp is added to the tank. The critical factor here is length of time of exposure to temperatures above 40°F. The control here is to maintain a rapid movement of the shrimp through the peeling department, using ice wherever possible.

The major problem comes after peeling, where the microbial counts can become quite large in a few hours. The wheeled tanks present a means of obtaining a good chill on the shrimp if there is ice water of a slush consistency in the tank before the shrimp are dumped in the tank.

The second processing hazard is incidental to plant design. That is, if there are any places where raw product lines cross peeled product lines, then there is the possibility of raw product contamination. Plant studies have shown that properly handled shrimp decrease their bacterial count during peeling. However, contamination from raw product serves to reverse the downward trend and increase the bacterial counts. This problem may be eliminated by reorganizing the flow lines where possible or by drip shrouds,

which catch the drip from raw product, preventing contamination of the finished product. The shroud, however, may become a source of contamination itself if it is not kept clean and well maintained.

Chapter 6

HAZARDS IN THE BREADING OPERATION

The hazards in the breading operation are: (1) process, (2) equipment, and (3) supplemental ingredients. This is shown in Diagram 6.

The process hazard develops when a contaminated batch of shrimp is breaded immediately before a batch of shrimp which has not been contaminated. The microbial contamination from the first batch of shrimp is picked up by the batter and the breading, and then transferred to the good batch of shrimp.

The problems due to equipment are the same as mentioned earlier. That is, the equipment serves as a source of microbial contamination of the product when it is not properly cleaned and sanitized. Microbial testing has shown the following locations on the respective pieces of equipment to be potential sources of bacterial contamination:

- (1) sorting belt: frame and belt supports, drive belt, belt drive shaft, belt idler shaft;
- (2) dump belt (goes from tank to sorting belt): plastic mesh belt;
- (3) batter machine: wire belt, belt drive and idler shaft, batter return trough, batter filter and filter sump, batter pump housing and impeller, batter hoses, batter delivery tube, and batter distributing trough;

- (4) breeding machine: solid and wire belts, belt drive and idler shafts, breeding bin and return auger, rollers, blowers, motors and hoses.

The critical control for all of this equipment is a good effective sanitation program. The sanitation program will be discussed in detail in Chapter 10.

The hazards from personnel are the same as those discussed earlier, and will also be covered in detail in Chapter 9.

The hazards from the additional ingredients do not come from the ingredients themselves. However, there is one very important exception to this. That exception is a batter mix which contains eggs or egg products. Bacterial surveillance has occasionally detected viable salmonella in the batter mixes. Thus, the contamination of frozen raw breaded shrimp with salmonella from the batter is a remote, but definitely possible hazard. Other bacteria of importance such as Escherichia coli and coagulase positive Staphylococcus could also gain access via this route.

The same situation is also valid with breeding but, owing to the dry application of the breeding, the potential as a hazard is reduced.

The best control is monitoring the quality of the batter and breeding as it is supplied by the manufacturer.

The batter and breeding present a hazard to the product from another standpoint. That is, mishandling in dry storage and in its addition to the line. The batter and breeding may pick up contamination in poor warehouse



Figure 7. The shrimp being sorted before breeding.

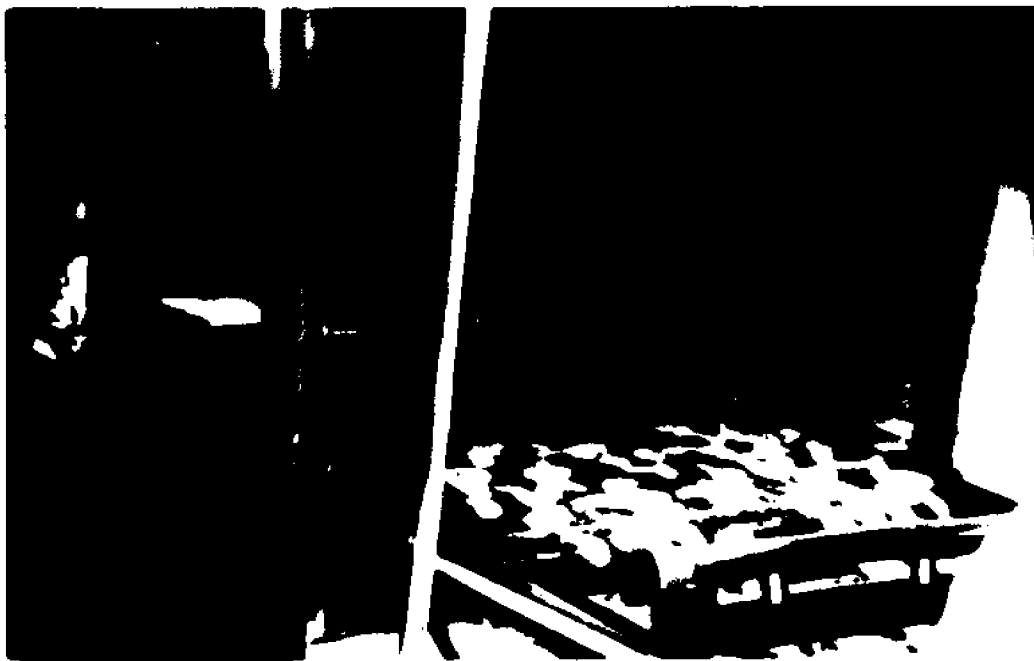


Figure 8. The application of batter and breading to the shrimp.

conditions due to the exposure to dust, moisture, rodents, and insects. The same is true of mishandling the processing area where moisture and microbial contamination are most likely to occur. The application of good manufacturing guidelines will substantially reduce this possibility.

In the processing area, one of the worst situations is the failure to strip the outer bags of the two before using the batter and breading. Control of these problems requires good supervision.

The final problem in this area is one that can produce a disastrous result if it gets out of control. This hazard is the failure to properly handle and care for the liquid batter. As pointed out in the review of literature, the liquid batter is an excellent medium for bacterial growth. The bacteria are present in the batter mix and, all too often, the batter equipment. The batter also acquires bacteria from the shrimp.

The batter must be kept well refrigerated (40°F or less) if the bacterial growth is to be inhibited. The Good manufacturing Practices recommend that the batter be discarded every 2 hours if mechanical refrigeration is not used. If mechanical refrigeration is available, then the batter should be discarded every 4 hours.

The best control for batter hazards is adherence to the Good Manufacturing Practices and the monitoring of batter temperatures.

Chapter 7

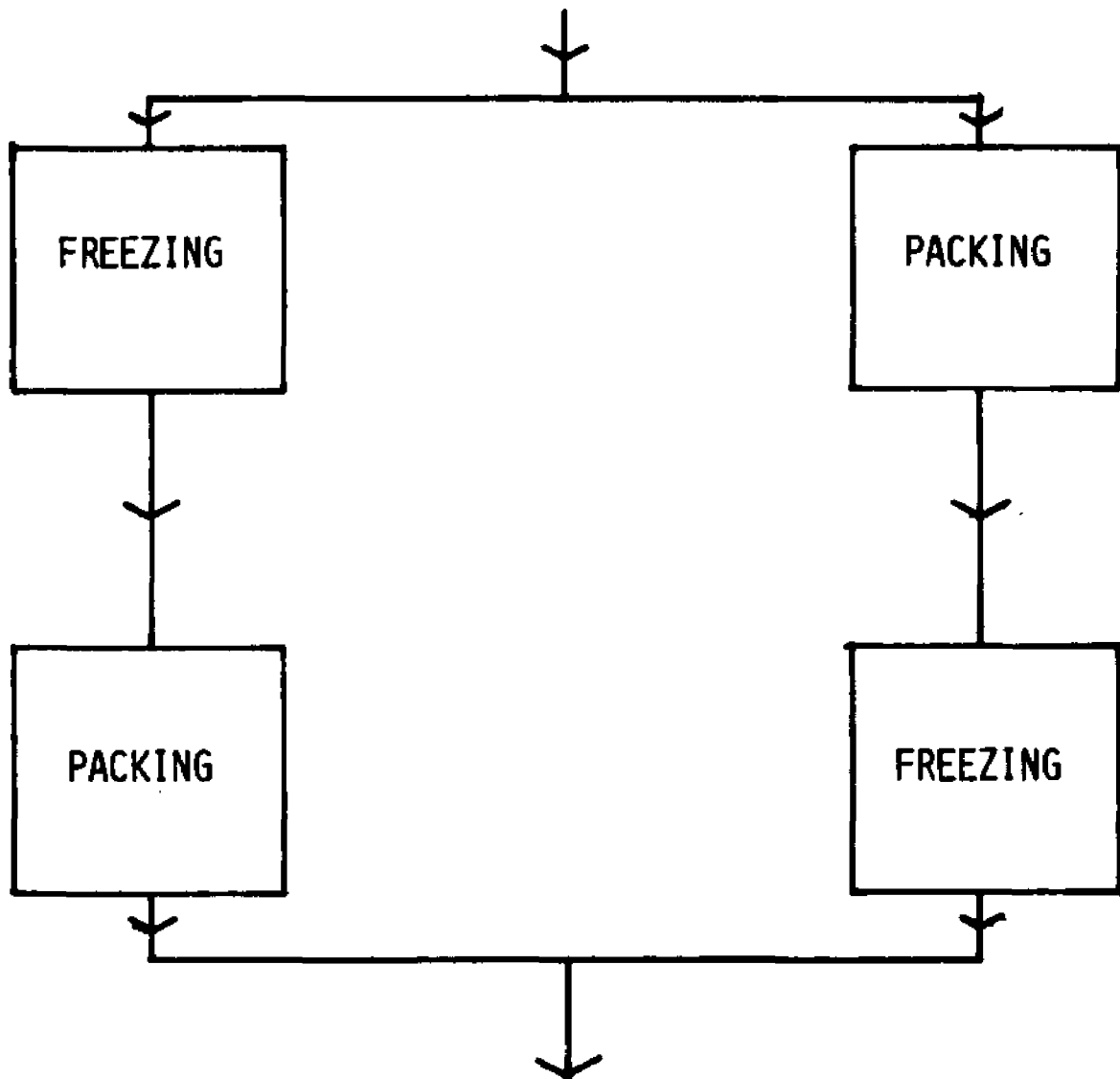
PRESERVATION OPERATIONS

This is the operation or series of operations which stabilizes the character of the product. The operations here may proceed with packing, then freezing or individual quick freezing, then packing. The hazards are less with the second procedure, but for this procedure to be instituted, major construction and facility changes and resulting construction costs are involved.

The hazards of packing come from (a) equipment sanitation, (b) personnel sanitation, and (c) delay of entry of packed product into the freezers. This is indicated in Diagram 6 and Table IV.

Table IV. Packing and Preservation HACCP (650 inspections)

Hazard	Inspections exceeding FDA microbiological guidelines (%)				
	Total plate count	Total coliforms	Fecal coliforms	Coagulase positive Staphylococcus	Salmonella-Shigella
Packing table	5	0	3	0	rare
Freezer	0	0	0	0	0
Racks	9	4	1	87	0
Hot breaded shrimp	28	15	7	64	rare
Frozen breaded shrimp	25	12	5	59	rare



EQUIPMENT SANITATION
PERSONNEL SANITATION
EXPOSURE TO TEMPERATURES ABOVE 40°F
WAITING PERIOD BEFORE ENTRY INTO FREEZER

DIAGRAM 6
PRESERVATION HAZARDS



Figure 9. Packing breaded shrimp.



Figure 10. A packing line for breaded shrimp.

The equipment involved here consists of a packing belt, scaler, box former, box wrapper or sealer, or freezer racks. The hazardous areas for each piece of equipment are as follows: (1) packing table--packing belt, table sides, belt drive and idler shafts; (2) scaler--dirty scale pans; (3) box former--accumulation of trash and debris, dirt and filth on contact surfaces; (4) box wrappers and sealers--accumulation of spilled shrimp and breading; and (5) freezer racks--frames and trays.

All of these equipment hazards can be eliminated with a thorough sanitation program. The freezer racks do find occasional use for freezing green headless and peeled meats. Microbial evaluation has shown those racks to be particularly susceptible to contamination with coagulase positive *Staphylococcus*. For this reason, these racks need a regular and thorough cleansing to remove wax, glue, shrimp juices, and any bacteria present.

Again, personnel can contaminate the product by failure to practice good sanitation. The contamination can be the reason for rejection of a product that, until then, was of acceptable quality. The control of personnel sanitation is discussed in Chapter 9.

The final hazard is delay of entry of the product into the freezer. This may be caused by equipment breakdown, labor shortage, and packing of over- and under-sized shrimp owing to poor grading. Whatever the cause, the delay gives

time for bacterial growth to occur, and thus reduces the quality of the product flow and effective supervision of product handling. This hazard is not too likely to occur with instant quick frozen (IQF) processing.

Chapter 8

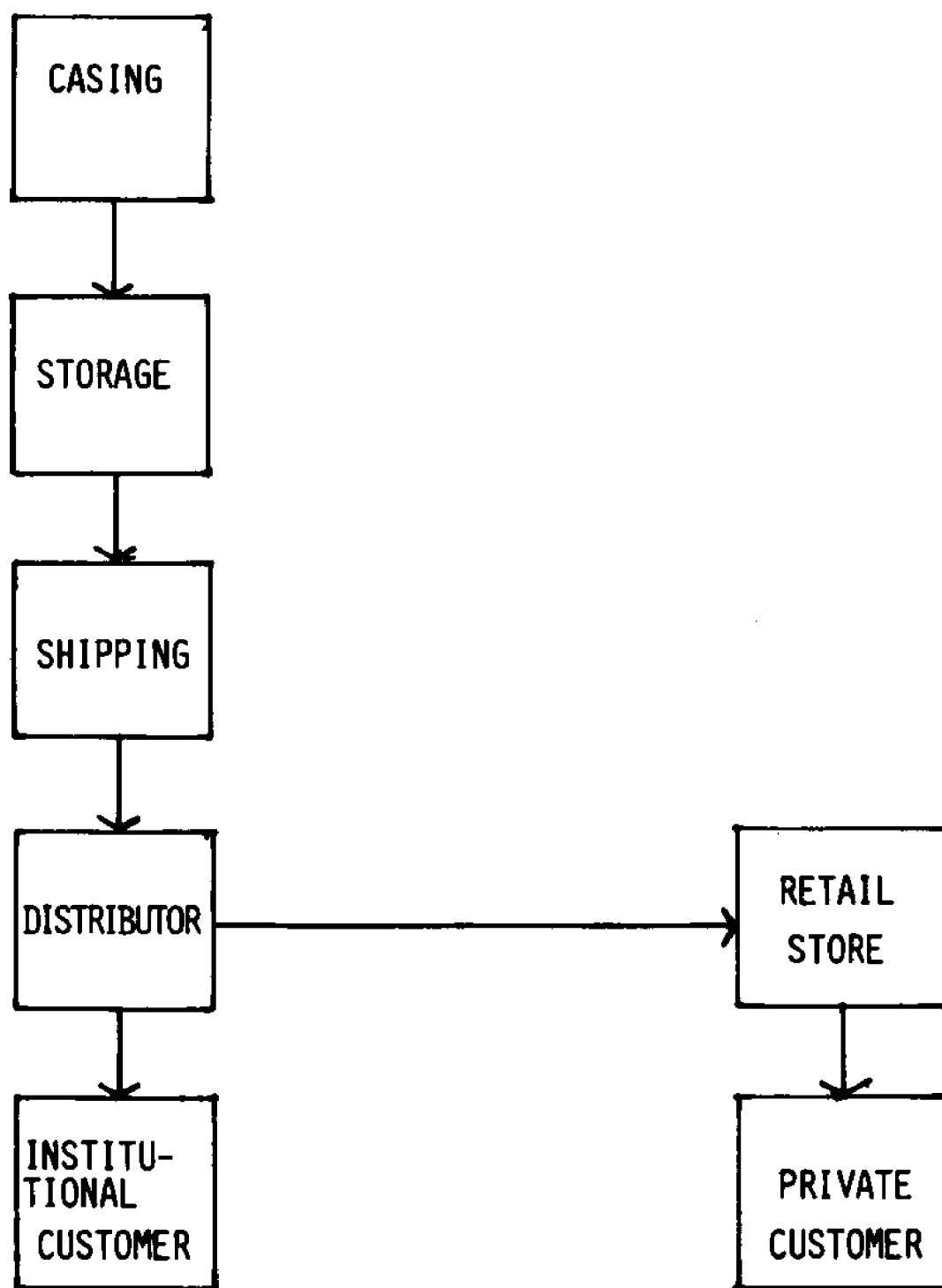
CASING THROUGH DISTRIBUTION

From the frozen package there are two hazards which may appear as the product is cased, stored, distributed, sold and consumed. These hazards apply to the entire chain of operations shown in Diagram 7. The microbiology of these hazards is shown in Table V.

Table V. Distributive and Consumer HACCP (225 inspections)

Hazard	Inspections exceeding FDA microbiological guidelines (%)				
	Total plate count	Total coliforms	Fecal coliforms	Coagulase positive Staphylococcus	Salmonella-Shigella
Physical damage	16	10	6	72	rare
Shipping mishandling	69	10	8	61	rare
Return merchandise	84	14	12	67	rare
Thaw and refrozen	88	17	2	89	rare
Consumer complaint (illness only)	93	22	16	78	rare

The first hazard is that of physical damage due to rough handling. This can result in microbial contamination due to disruption of the integrity of the packing materials.



TIME OF EXPOSURE TO TEMPERATURE ABOVE 0°F
OCCURRENCE OF PHYSICAL DAMAGE
STORAGE AND DISPLAY TEMPERATURES
CHEMICAL AND MICROBIOLOGICAL DAMAGE
DUE TO THAWING AND SLOW REFREEZING

DIAGRAM 7
HAZARDS OF DISTRIBUTION

The physical damage may occur any place at any time. The problem is in part carelessness and lack of proper supervision. Physical damage may result from drops, spills, being run into with a forklift, etc. Not all physical damage is avoidable. Damage from accidents in shipment may be the results of actions of personnel not involved in the handling of the product, i.e., highway accidents. The problem, then, is to determine if the product can be salvaged. The controls available here are supervision of product handling and assignment of responsibility for the safety and financial loss of the product. This is a sensitive area that is best handled on a case-by-case basis with the person or firm who had custody of the merchandise at the time of damage.

The same controls apply to the second hazard, which is, specifically, the failure to keep the product well frozen, usually followed by slow refreezing. This results in a product with high microbial population and a discolored appearance. The bacteria grow while the product is in the thawed state. The degree of growth is determined by the highest temperature which the product reaches, the time the product is at that temperature, and the time required to lower the temperature to a point (28°F) where the microbial growth is inhibited.

The discoloration is formed by a complex series of reactions involving organic, inorganic and metallic components of the shrimp, breading and batter. There is quite a variety in the colors produced, including black, yellow,

green, and purple. The industrial trend is to consider this as merchandise damaged in distribution and therefore the party who had possession at the time of damage is considered financially responsible.

There is a final problem that presents a very particular hazard of its own. The hazard of consumer abuses has no critical control that can be implemented by the manufacturer. Instructions can be and are given on the handling and preparation of the product. If these instructions are not followed, then who is responsible? The consumer should be, but this is not always the case. In most instances of returned merchandise, consumer abuse is not allowed as a basis for refunds or credit.

Chapter 9

SPECIAL HAZARDS

In the food processing plant, there are facilities and equipment that represent special hazards. These hazards are not associated with any one process or area of the plant because they can and do occur anywhere in the plant. These hazards fall into three categories, which are: (1) plant construction and grounds, (2) small equipment, and (3) personnel.

The plant grounds and construction are included in parts 128 and 128A of the Code of Federal Regulations. The items covered in the Good Manufacturing Practices include: improperly stored equipment; litter; waste; refuse; uncut weeds in the immediate vicinity of the plant which can harbor rodents, insects and other pests; dusty roads, yards and parking lots; and inadequate drainage. These problem areas should be eliminated wherever possible, otherwise they become a continuing source of rodents, insects, bacteria, and non-living contaminants. If the hazard is not on the property controlled by the plant, then inspection and appropriate control measures within the confines of the plant are the only means of handling the situation. Some of the control measures involved are the use of air screens, external pest

control, rodent and insect proof self-closing doors, and fencing. The microbiology of the hazards is illustrated in Table VI. Some of the hazards or their controls are illustrated in the various figures.

Table VI. Special Plant HACCP (650 inspections)

Hazard	Inspections exceeding FDA microbiological guidelines (%)				
	Total plate count	Total coliforms	Fecal coliforms	Coagulase positive Staphylococcus	Salmonella-Shigella
Personnel hands	rare	63	47	84	5
Hair	rare	35	18	100	rare
Clothing	rare	49	10	100	rare
Small equipment pans	78	37	15	93	1
Tubs	78	40	9	90	1
Building construction airborne contamination	0	1	0	5	0
Rodent contamination	0	25	18	10	55
Insect contamination	0	1	1	25	50

The plant construction involves numerous details and considerations. The older plants are much more likely to have deficiencies than plants which have been either remodeled or have been recently constructed. The following items are specifically pointed out in the Good Manufacturing Practices as requirements for plant design and construction:

1. Provide sufficient space for the placement of

equipment and storage of materials as is necessary for sanitary operations and production of a safe food. The floors, walls and ceilings shall be of such construction as to be adequately cleanable, and shall be kept clean and in good repair. Fixtures, ducts and pipes shall not be so suspended over working areas that drip or condensate may contaminate foods, raw materials, or food-contact surfaces. Aisles or working spaces between equipment and between equipment and walls shall be unobstructed and of sufficient width to permit employees to perform their duties without contamination of food or food-contact surfaces with clothing or personal contact.

2. Provide separation by partition, location or other effective means for those operations which may cause contamination of food products with undesirable microorganisms, chemical filth, or other extraneous material.

3. Provide adequate lighting to hand-washing areas, dressing and locker rooms, toilet rooms, and to all areas where food and food ingredients are examined, processed or stored, and where equipment and utensils are cleaned. Light bulbs, fixtures and skylights or other glass suspended over exposed food in any step of preparation shall be of the safety type or otherwise protected to prevent food contamination in case of breakage.

4. Provide adequate ventilation or control equipment to minimize odors and noxious fumes (including steam) in areas where they may contaminate food. Such ventilation or

control equipment shall not create conditions that may contribute to food contamination by airborne contaminants.

5. Provide where necessary effective screening or other protection against birds, animals, and vermin (including, but not limited to insects and rodents).

6. Unloading platforms shall be made of readily cleanable materials and equipped with drainage facilities adequate to accommodate all seepage and wash water.

7. The product shall be so processed as to prevent contamination by exposure to areas involved in earlier processing steps, refuse, or other objectionable areas.

Sanitary Facilities and Controls

The sanitary facilities and controls are designed to prevent and control microbial contamination. These facilities, when improperly designed and/or abused, become a source of contamination.

The following guidelines are for the control of sanitary facilities as a source of contamination. Each plant shall be equipped with adequate sanitary facilities and accommodations including but not limited to the following:

1. Water Supply. The water supply shall be sufficient for the operations intended and shall be derived from an adequate source. Any water that contacts food or food-contact surfaces shall be safe and of adequate sanitary quality. Running water at a suitable temperature and under pressure as needed shall be provided in all areas where the

processing of food, the cleaning of equipment, utensils, or containers, or employee sanitary facilities require.

2. Sewage Disposal. Sewage disposal shall be made into an adequate sewerage system or disposed of through other adequate means.

3. Plumbing. Plumbing shall be of adequate size and design and adequately installed and maintained to:

- a. carry sufficient quantities of water to required locations throughout the plant;
- b. properly convey sewage and liquid disposable waste from the plant;
- c. not constitute a source of contamination to foods, food products or ingredients, water supplies, equipment, or utensils or create an insanitary condition;
- d. provide adequate floor drainage in all areas where floors are subject to flooding-type cleaning or where normal operations release or discharge water or other liquid waste on the floor.

4. Toilet Facilities. Each plant shall provide its employees with adequate toilet and associated hand-washing facilities within the plant. Toilet rooms shall be furnished with toilet tissue. The facilities shall be maintained in a sanitary condition and kept in good repair at all times. Doors in toilet rooms shall be self-closing, and shall not open directly into areas where food is exposed to airborne contamination, except where alternate means have been taken to prevent such contamination, such as double doors, positive air flow systems, etc. Signs shall be posted directing employees to wash their hands with cleaning soap or detergents after using the toilet.

5. Hand Washing Facilities. Adequate and convenient facilities for hand washing and, where appropriate, hand sanitizing shall be provided at each location in the plant where good sanitary practices require employees to wash or sanitize and dry their hands. Such facilities shall be furnished with running water at a suitable temperature for hand washing, effective hand cleaning and sanitizing operations, sanitary towel service or suitable drying devices, and, where appropriate, easily cleanable waste receptacles.

6. Rubbish and Offal Disposal. Rubbish and any offal shall be so conveyed, stored and disposed of as to minimize the development of odor, prevent waste from becoming an attractant and harborage or breeding place for vermin, prevent contamination of food, food-contact surfaces, ground surfaces, and water supplies.

The Good Manufacturing Practices for Frozen Raw Breaded Shrimp also state:

- a) Adequate hand-washing and sanitizing facilities shall be located in the processing area easily accessible from the peeling and subsequent processing operations.
- b) Readily understandable signs directing employees handling shrimp to wash and sanitize their hands after each absence from post of duty shall be conspicuously posted in the peeling and subsequent processing areas and elsewhere in the plant as conditions require.
- c) Offal, debris or refuse from any source whatsoever shall not be allowed to accumulate. Offal shall be placed in suitable covered containers and shall be removed not less than once daily or shall be continuously removed by flumes, conveyors, or chutes.

The only controls that are applicable here are inspection and correction as is possible. In older plants, the

best means of correction may well be the construction of a new plant, but this can be done only if the circumstances permit.

In one certain plant, there are numerous cracks and gaps in the floors and walls. This particular plant is located immediately adjacent to (within 50 feet) of several sets of very heavily used railroad tracks. The railroad traffic is definitely one of the causes of the cracks and separations in the walls and floors. Since building a new plant was not feasible at that time, the only solution was to keep the cracks, etc., filled. This applies to all the guidelines above. That is, the deficiencies need to be corrected, yet common sense must be applied so as not to overburden the abilities of the company.

Another general hazard area is the small equipment which is used throughout the plant. Examples of such equipment are knives, cutting boards, pans, tubs, trays, etc. Hazards from this equipment can be in the form of foreign materials, filth, and bacteria. The foreign material can come from the wood used in cutting boards and knife handles. For the most part, wood has been eliminated at the present time. The filth and bacteria both are a result of improper and ineffective cleaning. Sanitizing before use helps, but it is not an effective replacement for a good cleaning. The control here is both physical and microbiological inspection.

The final general hazard is not restricted to just the breaded shrimp industry. It occurs anywhere food is



Figure 11. A hand washing station.



Figure 12. An iodine dip solution for hands.

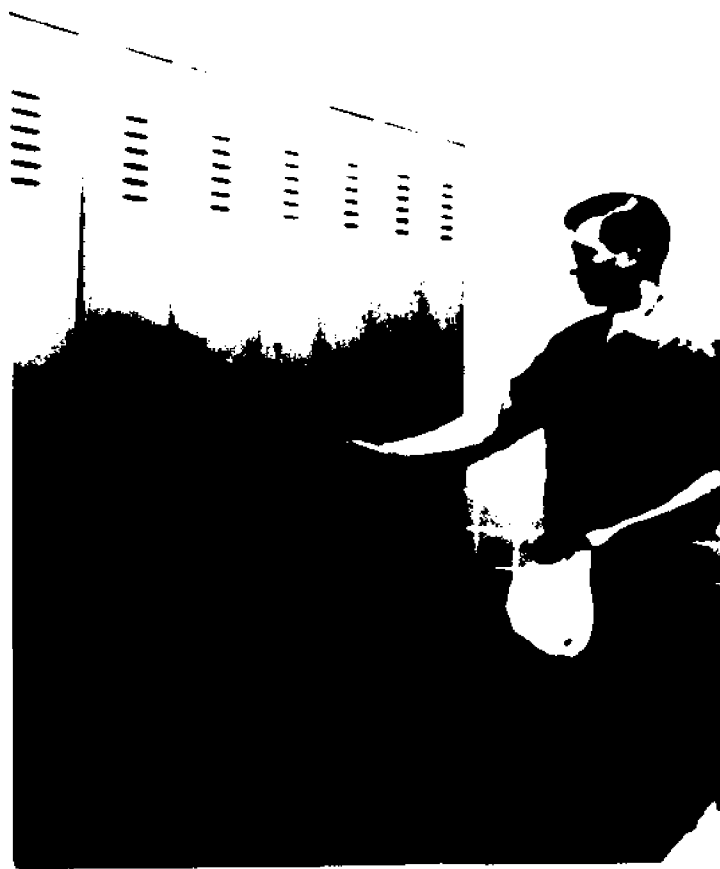


Figure 13. A clean, well-lit locker room.

processed. The human source of contamination is a two-fold mechanism.

The human body is, first, a physical means of transportation and, second, a reservoir for the contaminating organisms. An example of the first mode of action would be the transportation of any of the pathogens from a sickroom at home or the hospital to the plant and the product. The action as a reservoir is illustrated by the contamination of the product with bacteria from an active source on the body of a worker. The Good Manufacturing Practices again goes into great detail on what needs to be controlled.

The Good Manufacturing Practices states that the plant management shall take all reasonable measures and precautions to assure the following:

1. Disease Control. No person affected by a disease in a communicable form or while a carrier of such disease or while with boils, sores, infected wounds or other abnormal sources of microbiological contamination shall work in a food plant in any capacity in which there is a reasonable possibility of food or food ingredients becoming contaminated by such a person or of disease being transmitted by such a person to other individuals.

2. Cleanliness. All persons while working in direct contact with food preparation, food ingredients or surfaces coming into contact therewith shall:

- a. Wear clean outer garments, maintain a high degree of personal cleanliness, and conform to

hygienic practices while on duty to the extent necessary to prevent contamination of food products.

b. Wash their hands thoroughly (and sanitize if necessary to prevent contamination by undesirable microorganisms) in an adequate hand-washing facility before starting work, after each absence from the work station, and at any other time when the hands may have become soiled or contaminated.

c. Remove all insecure jewelry, and during periods where food is manipulated by hand, remove from hands any jewelry that cannot be adequately sanitized.

d. If gloves are used in food handling, maintain them in an intact, clean, and sanitary condition. Such gloves should be of an impregnable material except where their usage would be inappropriate or incompatible with the work involved.

e. Wear hair nets, head bands, caps, or other effective hair restraints.

f. Not store clothing or other personal belongings, eat food or drink beverages, use tobacco in any form in areas where food or food ingredients are exposed or in areas used for washing equipment or utensils.

g. Take any other precautions to prevent contamination of foods with microorganisms or foreign substances including but not limited to perspiration, hair, cosmetics, tobacco, chemicals, and medicants.

3. Education and Training. Personnel responsible for identifying sanitation failures or food contamination should have a background of education or experience or a combination thereof, to provide a level of competency necessary for production of a clean and safe food. Food handlers and supervisors should receive appropriate training in proper food handling techniques and food-protection principles and should be cognizant of the danger of poor personal hygiene and insanitary practices.

4. Supervision. Responsibility for assuring compliance by all personnel with all requirements of this part 128 shall be clearly assigned to competent supervisory personnel.

Chapter 10

DISCUSSION

Results presented in the previous chapters are those of generalized hazards. The specific results of a hazard analysis require that the analysis be made and applied in the specific plant where the shrimp are being processed. While two plants may be quite similar, there may be differences in design, equipment, and management which will drastically alter the results and implementation of HACCP. Therefore, the necessary controls will also be altered.

An example is found in the variations between the two plants in which most of these investigations were performed. In plant A, all incoming shrimp are purchased in the frozen green headless form, while in plant B the majority of the incoming shrimp are purchased fresh. Plant A does not have any of the hazards associated with the wood crates used for fresh shrimp. For practical applications, HACCP is specific for the plant, process, equipment, and management involved.

The hazards and their respective control measures have been pointed out in Chapters 3 through 9. Chapters 3 and 4 apply only to those companies whose operations include the harvesting and primary handling of the product.

The first critical control point for companies not

handling these operations is the evaluation of the incoming shrimp. If the raw material is inferior, then the critical controls should keep it from getting worse, but they are not likely to result in an improvement in the quality of the product.

The critical controls fall into three categories:

(1) raw product controls, (2) processing controls, and (3) sanitation controls. There is no place in the production of raw breaded shrimp where these controls are not applicable.

Raw Product Controls

Continuous caution must be exerted in the procurement and purchase of raw materials: know what you are getting, even if quality assurance tests are necessary. Develop a working relationship with the brokers and suppliers from whom the raw products are obtained; also, inspections of the materials should be made as they are received. Inspections should involve physical examination, organoleptic evaluation, and microbiological testing. When the product is physically examined, some of the attributes to examine are: color, size (count per pound), total weight, texture (soft and mushy versus firm), condition of the shell, odor, broken shrimp, and the size and number of pieces.

These defects offer a rough guide to the quality of the products because they serve as an indication of how the shrimp were probably handled prior to acquisition by the

breeder. The rougher (poorer quality) the packs, the more potential for poor microbial quality. This is, however, a rough guide that is not always dependable.

The organoleptic evaluation correlates even more closely with the microbial quality. The items to evaluate include taste, odor, appearance, and texture. Odors, colors, textures, and flavors which vary from the "normal" for shrimp are a strong indicator of mishandling, possible decomposition and heavy microbial loads. The person making the organoleptic evaluation should be well trained and experienced as there is considerable variation in the characteristic appearance, flavor and texture of the various species of shrimp available on the world markets.

Microbiological testing indicates the bacterial quality of the product, and the combined results of all tests, when compared with the company standards, indicate whether the product is acceptable. These standards are adopted by the management of the company and are usually modified as required by varying market conditions. For example, when shrimp are scarce, the quality standards may be lowered in order to assure a sufficient supply of shrimp to keep the plant in operation, or the standards may rise when there is a surplus of shrimp to protect the final product quality. The decision to change these standards is usually the prerogative of top level management after discussions with the company scientific director.

Once the raw materials are obtained, the critical

controls under (2) and (3) above become effective. These controls are under the supervision of the quality assurance department together with cooperation from production and management.

A supervisory problem may arise unless specific duties are assigned to each employee under the management of the quality assurance and production divisions. Friction must be avoided at all costs. The development of this conflict, for whatever reason, is disruptive to the company goals in terms of production, quality, and company income. Should this situation arise, management should take that action necessary to resolve the situation, including the dismissal of guilty parties if needed. The conflict between quality assurance and production is always present, but as long as it is not a disruptive influence to the company operations, the friction is not a direct cause for concern.

Implementation of the Controls

The implementation of controls of the various hazards depends on the company and its managerial organization. In the majority of the companies, the surveillance of the controls will be handled by quality assurance with the actual implementation being handled by production.

For example, the sanitation is checked by quality assurance, but the actual clean-up work is done either by a special crew under production supervision or by production personnel at the end of the day.

When the controls are not working (i.e., a situation is out of control or off-standard), the supervisor of the department involved is notified. If the situation is still out of control, notification is made in turn to the next higher level of management until the situation is either corrected or the line is shut down.

Time for the correction to be made should be allowed before reporting the situation to the next higher manager, supervisor, etc. The time allowed depends on the situation. Included in this period of time is the time used in rechecking the out-of-control item. Records should be kept on the situation and its resolution. The quality assurance supervisor or director should have the authority to shut down the line if the production supervisor refuses to take corrective action.

The evaluation of the controls is handled by the quality assurance technician. Some of the process controls are checked by the line technician at the time of their line check. Other process controls may be checked by a special technician, whose job it is to check those controls. At any time the quality assurance personnel see an out-of-control situation, they should report it immediately to either their supervisor or the supervisor of the department involved, according to company policy.

Sanitation controls are usually checked by the sanitationarian who reports deficiencies to his supervisor and the production supervisor in charge of clean-up. Again, all

quality assurance personnel are expected to report any off-standard situation they encounter.

The Controls

As stated earlier, the controls after the acquisition of the raw product are either process or sanitation controls. Both classes of the controls are outlined in the Good Manufacturing Practices, parts 128 and 128E, Title 21, the Code of Federal Regulations (CFR). Some of these practices and controls are shown in the various illustrations in this chapter.

The results of the hazard analysis indicate that several situations exist. First, the indicator organisms can tell the history of the product if the microbial background is known; that is to say, the total coliforms, fecal coliforms, coagulase positive *Staphylococcus*, and total plate counts will indicate if the product was mishandled or not, if the microbiology of the raw material is known.

The term "indicated" is used here since the field of statistics tells us that the only way to have an absolute picture is through 100% sampling, which is a fiscal and physically impossible situation to achieve.

Second, the final product analysis gives a very clear warning when the controls are not functioning properly by increased counts, and by the presence of certain pathogenic organisms. Those pathogens most likely to show up are coagulase positive *Staphylococcus*, *Salmonella*, and to a



Figure 14. Dipping hands in iodine solution.



Figure 15. Inspection of equipment.



Figure 16. High pressure cleaning of equipment.



Figure 17. Cleaning batter equipment.



Figure 18. Inspection of hands before starting work.



Figure 19. Icing of shrimp during processing.



Figure 20. Dipping hands in iodine solution.

lesser degree Shigella. Again, it must be emphasized that the microbial background is of extreme importance. The author has encountered Salmonella typhimurium (group C1) on several occasions in the finished product. By referral to production and quality assurance records, the source was found to be frozen peeled and deveined shrimp that were used before testing by quality assurance. This also points out the need for cooperation between quality assurance, production, and management.

Third, the application of good controls as outlined earlier will minimize the bacterial contamination of the product.

Fourth, when a particular hazard gets out of control, certain organisms will indicate the situation. For example, if hand sanitation should become lax, then there will probably be increases in the coagulase positive *Staphylococcus*, total coliform, and fecal coliform populations which would serve as an alarm to the out-of-control situation, as well as the fact that the personnel are not being properly observed or supervised.

Fifth, the detection of a high incidence of any or all of the pathogens is an indication of serious control failures.

Sixth, the most critical controls involve: (1) equipment and personnel sanitation, (2) time-temperature relationships during processing, and (3) raw material inspection before using.

These conclusions, when used together with the knowledge of the plant, process, personnel, equipment, and management within a particular company, can lead to the rapid identification of control failures and their correction.

In relationship to the pathogenic bacteria, there are several observations that may be made. First, the coagulase positive *Staphylococcus* is the pathogen which occurs in frozen raw breaded shrimp most frequently. Second, the *Salmonellae* because of their virulence are very important, but their occurrence is irregular, i.e., it does not follow any regular pattern except when control over one or more hazards has been lost. Third, the *Shigellae* are found only rarely in frozen raw breaded shrimp. Fourth, the importance of *Vibrio parahaemolyticus* is still undefined. Even though this organism is occasionally found in shrimp, its potential as a health hazard in frozen raw breaded shrimp has not yet been critically evaluated.

The last item to discuss here is the quality philosophy of the company. This philosophy varies from company to company and within the company. For any technical control program to work, the philosophy behind the program and the management must be sincere. If this is not the case, then the program will sooner or later be shown up for what it really is--a charade. This occurs because the product leaving the plant reflects its quality when examined.

SUMMARY

New laws of the U.S. Food and Drug Administration require the development of specialized techniques for the inspection of various types of food processing industries. The Hazard Analysis Critical Control Points concept is being emphasized as a new technique for plant evaluation and control. This investigation was designed to develop specific inspectional procedures for locating HACCP's and devise methods for their avoidance during the manufacture of frozen raw breaded shrimp.

Every industry processing a particular type of food product has hazards that are specific for the processes used in the manufacture of that food, and the severity and extent of these hazards usually vary from plant to plant. Also, local problems exist which are products of the environment and specific constitution of an individual plant. However, HACCP inspection is designed for the control of hazards during the preparation of a particular food, and it eliminates procedural and implementative problems due to individual plant variation, even though lack of control of these points may result in a potential health danger from the product.

The procedure is not new, but the idea of applying this concept to quality assurance in the food industry is recent. Briefly, the principle is to treat the process and

its environment as a single system, including all inputs into that system.

In searching for HACCP areas during the manufacture of frozen raw breaded shrimp, investigations were made at every location where the product could become damaged, contaminated or adulterated from the time the shrimp are removed from the water until they reach the retail outlets.

It would serve no purpose to manufacture a food under highly sanitary conditions and good manufacturing practices without using good quality raw materials. In the shrimp industry, an unreasonable amount of raw material may become inferior through mishandling between the time of catch and transportation to the processor. The quality of the shrimp when removed from the water, the method of sorting and washing, and proper refrigeration soon after catching are contributory factors for evaluating their quality when the product arrives at the plant. Negligence in the handling of the raw material will completely defeat any efforts to produce a safe, wholesome food in the processing plant.

Therefore, to develop an HACCP program for raw breaded shrimp, it is necessary to study the flow of shrimp from shipboard through preparation, processing, packaging, freezing and distribution.

When the concept is applied, the first requirement is an inventory or list of hazard producing operations.

The first step is the evaluation of the hazards

present in the raw material, and this evaluation should be completed first. It is one of the major determinants of the presence of hazards due to the manufacturing operations, and personnel and management practices.

All hazards listed below have been identified micro-biologically, and many of these may be the source of multiple problems. An example of this is a batter machine which because of its complexity has a number of sensitive areas requiring effective cleaning and sanitizing. Any one of these sensitive areas which does not receive effective sanitation may and can cause product contamination.

Shipboard hazards are: fishing in and the use of polluted water, unclean fishing decks and utensils, and improperly sanitized and refrigerated holds.

Problems associated with packing houses are: contaminated wash tanks, filthy and damaged wooden crates, and mishandled and improperly used ice.

Dangers inherent in the product receiving and preparation operations are: the use of non-potable water; contaminated and dirty equipment including wash tanks, graders, peeling machines, portable tanks, sorting belts, batter tanks and machines, and breading machines; and the improper handling of breading and both dry and liquid batter.

Hazards associated with the packing and preserving operations arise in equipment such as the packing tables, wrapping and sealing machines, freezers and freezer racks, and from failure to reduce the product temperature quickly

enough.

Problems occurring during distribution are physical damage and exposure to temperatures above 0°F.

Most hazards are more or less confined to one area of operations, but there are some hazards that occur throughout the entire process. These include unnecessary exposure to temperatures above 40°F, poor personnel practices, improper sanitation for small equipment, poor building design and construction, and inadequate animal control.

All of these hazards may be considered potential problems in relation to pathogenic bacteria because of: (1) the formation of a suitable environment for the growth of any pathogenic organisms which may be present, (2) failure to remove or destroy any disease-producing organisms present on the equipment, and (3) direct contamination from raw materials, personnel, and any animals that might be in the plant. The actual hazard develops when any one or a combination of these factors achieves an active status.

The various controls for these hazards follow the format of a monitor system, a reporting system (feedback), and a procedure for corrective action. In general terms, the quality assurance testing and inspection is the monitoring system, while the records and reports are the feedback system, and the corrective action takes the form of proper supervision. Special hazards may be eliminated by the methods described earlier for each particular problem.

Good Manufacturing Practices are the foundation of

the entire control system, and work effectively only when supported with good supervision and quality assurance testing and inspecting.

The results of the inventory can then be used as the system for establishing controls to either eliminate the hazard completely or utilize positive action to effect control of the hazard.

Once the controls are identified, the next step is to organize the procedures for their operation. The establishment of the controls involves defining the control mechanisms. Who is responsible for making the checks; when, where and how are they made? Additionally, if samples are taken, a determination must be made as to how much or how many. These are questions that must be answered by both technical and management personnel. Without the support of management, the controls will not be effective.

The checks themselves will best be those determined by the technical staff to be the best available for application in the particular situation where the control is needed.

Once the controls, which include incoming product analysis, proper record keeping, product identification, and correlation of microbiological test results, are established the HACCP system can provide a detailed picture of the day-to-day conditions in the plant as well as the effectiveness of the maintenance of hazardous conditions within their specified parameters. The parameters are those established by either the company or the FDA as either quality guidelines

standards. The use of the HACCP controls in this manner is also dependent upon the sincerity of the company management toward the quality of their products.

In some instances, a hazard may be completely eliminated rather than controlled. (When this is possible, it is the preferred method.)

In conclusion, for the HACCP concept to work effectively, it should be applied only in the specific production facility under consideration. If there is more than one plant, then an HACCP system should be developed for each facility, and the extent of quality control involved in the implementation of the HACCP system will vary with the individual needs of each plant in which the application is made.

If any manufacturer of frozen raw breaded shrimp will follow the plan outlined here for an HACCP program, it should be relatively simple to make any necessary modifications.

BIBLIOGRAPHY

1. Angelotti, Robert. 1973. Speech to the National Shrimp Breeders and Processors Association. "Standards for Frozen Seafoods." Baton Rouge, La.
2. Anonymous. 1974. "Hazard Analysis and Critical Control Point System (HACCP) for Breaded Shrimp Processing." Department of Food Science, Louisiana State University, Baton Rouge.
3. Bauman, Howard E. 1974. The HACCP Concept and Microbiological Hazard Categories. Food Technol. 28(9):30.
4. Bryan, Frank L. 1972. Emerging Foodborne Diseases. I. Their surveillance and epidemiology. II. Factors that contribute to outbreaks and their control. J. Milk Food Technol. 35:618.
5. Bryan, Frank L. 1974. Microbiological Food Hazards Today--Based on Epidemiological Information. Food Technol. 28(9):52.
6. Burrows, William. 1968. "Textbook of Microbiology." 19th ed. W. B. Saunders Co., Philadelphia.
7. Grodner, R. M., A. F. Novak, and W. C. Hopkins. 1975. Rapid Methodology Developed for the National Shrimp Breeders and Processors Association. Louisiana State University, Baton Rouge. Unpublished.
8. Grodner, R. M., and A. F. Novak. 1969. Personal communication. Louisiana State University, Baton Rouge.
9. Guthrie, Rufus K. 1972. Microorganisms and Man. In "Food Sanitation." The AVI Publishing Co., Westport, Conn.
10. Hall, Richard L. 1971. Information, Confidence, and Sanity in the Food Sciences. Food Technol. 25:270.
11. Horowitz, William (ed.). 1970. "Official Methods of Analysis." 11th ed. Association of Official Analytical Chemists, Washington, D.C.
12. Hubbard, Merton R. 1971. Management of Quality Control in the Food Industry. Quality Prog. Jan:22.

13. Joklik, Wolfgang K., and David T. Smith. 1972. "Zinsser Microbiology." 15th ed. Appleton-Century-Crofts, Meredith Corp., New York.
14. Kauffman, F. Leo. 1974. How FDA uses HACCP. Food Technol. 28(9):51.
15. Lawler, Frank K. 1973. FDA Launches New Quality Program. Food Engin. (4):65.
16. Lyng, Richard E. 1970. The Government's Role in Quality Assurance. Food Technol. 24:1094.
17. Majorack, Frank C. 1971. FDA's Quality Assurance Programs. Tools for Compliance. Food Technol. 25:1012.
18. National Academy of Science. 1969. Classification of Food Problems According to Risk. An evaluation of the Salmonella Problem. Pub. No. 1683, pp. 147. National Academy of Science, Washington, D.C.
19. National Academy of Science. 1973. "Toxicants Occurring Naturally in Foods." 2nd ed. National Academy of Science, Washington, D.C.
20. National Shrimp Breeders and Processors Association. 1974. Microbiological Survey, unpublished results. Louisiana State University, Baton Rouge.
21. Novak, Arthur F. 1973. Microbial Considerations in the Handling and Processing of Crustacean Shellfish. In "Microbiological Safety of Fishery Products," C. O. Chichester and H. D. Graham, eds. Academic Press, Inc., New York.
22. Olson, J. C., Jr., and L. R. Shelton. 1973. Microbiology of Prepared and Precooked Fishery Products. In "Microbiological Safety of Fishery Products," C. O. Chichester and H. D. Graham, eds. Academic Press, Inc., New York.
23. Pedraja, Rafael R. 1970. Change of Composition of Shrimp and Other Marine Animals During Processing. Food Technol. 24:1356.
24. Pedraja, Rafael R. 1973. Current Status of the Sanitary Quality of Fishery Products in the Western Hemisphere. In "Microbiological Safety of Fishery Products," C. O. Chichester and H. D. Graham, eds. Academic Press, Inc., New York.
25. Pedraja, Rafael R. 1973. Dynamic Sanitation in the Fish and Seafood Industry. Food Technol. 27(10):42.

26. Pedraja, Rafael R. 1975. A Quality Assurance Program in the Fish and Seafood Industry. Food Technol. 29(3):38.
27. Paterson, H. C., and R. E. Gunnerson. 1974. Microbiological Critical Control Points in Frozen Foods. Food Technol. 28(9):37.
28. Reddy, G. Venka. 1975. Personal Communication. Fishing Processors, Inc., Los Angeles.
29. Roberts, Henry P., and Dean H. Lockwood. 1973. FDA-Green Giant Quality Assurance Questions and Answers. Food Engin. (5):78.
30. Rogers, H. J. 1961. The dissimilation of high molecular weight substances. Vol. 2, pp. 257-318. In "The Bacteria," I. C. Gunsalus and R. Y. Stanier, eds. Academic Press, Inc., New York.
31. Sakaguchi, G. 1969. Botulism Type E. In "Foodborne Infection and Intoxication," H. Riemann, ed. Academic Press, Inc., New York.
32. Sakazaki, R. 1969. Halophilic Vibrio infection. In "Foodborne Infection and Intoxication," H. Riemann, ed. Academic Press, Inc., New York.
33. Skinner, C. M., and W. E. Henry. 1974. CQA Benefits Processor and His Market. Food Engin. (2):61.
34. Surkiewicz, Bernard F., James B. Hyndman, and Mary V. Yancey. 1967. Bacteriological Survey of the Frozen Prepared Foods Industry. Appl. Microbiol. 15(1):1.
35. Thatcher, F. S., and D. S. Clark, eds. 1968. I. Pathogenic organisms in foods. In "Microorganisms in Foods." University of Toronto, Toronto, Canada.
36. Toloday, Donald J. 1973. Personal Communication. Singleton Packing Corp., Tampa, Fla.
37. U.S. Department of Health, Education, and Welfare. 1969-1973. Foodborne Disease Outbreaks Annual Summary (1968, 1969, 1970, 1971, 1972). Center for Disease Control, Atlanta, Ga.
38. U.S. Department of Health, Education, and Welfare. 1969. Bacteriological Analytical Manual. 2nd ed. U.S. Food and Drug Administration, Washington, D.C.

39. U.S. Department of Health, Education, and Welfare. 1969-1970. Good Manufacturing Practices, Parts 128 and 128E, Title 21, Code of Federal Regulations. U.S. Food and Drug Administration, Washington, D.C.
40. U.S. Department of Health, Education, and Welfare. 1973. Chapter 20, Compliance Program Guidance Manual. U.S. Food and Drug Administration, Washington, D.C.
41. Wodicka, Virgil O. 1972. Wodicka Brings Message from FDA. Food Engin. (1):58.

APPENDIX

RAPID METHODS

The following material is the rapid methodology which has been developed for the National Shrimp Breeders Association. The methods are modifications of the AOAC procedures. Only the alterations are given in this appendix. This material comes from Dr. Robert M. Grodner, Department of Food Science, Louisiana State University (7). The rapid methods will be found on his page 118.

Ia. Rapid total plate count

- 1) Eugon Agar at 24 hours and 35°C.

IIa. Total coliform - Rapid

- 1) L.S.T. at 24 hours and 35°C.

IIIa. Fecal coliform - Rapid

- 1) L.S.T. at 24 hours and 44.5°C.

IVa. Staphylococcus aureus, Coagulase + Rapid

- 1) T.M.M. Broth at 24 hours and 44.5°C.

*For reporting purposes, please note if confirmed on V.J. and Coagulase.

MICROBIOLOGICAL REPORT

Company _____

Location	Date
----------	------

[illegible]

FISHKING PROCESSORS, INC.

Raw Product Report

Supplier _____

Date Received _____ Date Checked _____

Product

Listed weight					
Listed count					
Frozen appearance					
Thawed appearance					
Odor					
Texture					
Flavor					
Weight (actual)					
Count (actual)					
Broken: # per pkg. % by weight					
Defects number of sand veins					
Shell					
Off Color (specify)					
Parasites					
Other (specify)					
Action					

 Remarks: _____

Signed: _____

FISHKING PROCESSORS, INC.

Finished Product Report

Date Processed _____ Code _____

Date Tested _____ Raw Product Ref. # _____

Label				
Package size				
Count				
Total net wt				
Breeding %				
Temperature °F				
Wt loose brding				
Appearance				
Odor				
Flavor				
Texture				
Packaging				
Defects number of sand veins				
Balling				
Broken				
Incomp. breeding				
Incomp. cooking				
Adherence				
Size conformity				

Remarks: _____

Signed: _____

SAMPLE WORK SHEET

Source _____ Status: ☐ Raw ☐ Partially processed ☐ Finished

Product _____ Supplier _____ Date _____

Location from where sample was taken _____

Odor: ☐ Acceptable ☐ Unacceptable
 Appearance: ☐ Acceptable ☐ Unacceptable
 Preliminary action: _____

Bacteriological Tests:

Aerobic (total) plate count _____/gm	Odor: <input type="checkbox"/> Acceptable
Total coliforms..... _____/gm	<input type="checkbox"/> Unacceptable
Fecal coliforms..... _____/gm	Appearance: <input type="checkbox"/> Acceptable
Coagulase + Staphylococcus _____/gm	<input type="checkbox"/> Unacceptable
<u>Salmonella</u> and <u>Shigella</u> _____/gm	

% Breeding _____ Final Action _____

Processing time started _____ Initial Temperature _____ °F

Time finished _____ Final Temperature _____ °F

Processing time _____

Frozen on _____ date Shipped to customer on _____ date

See temperature charts _____

Remarks, follow-up action, complaints, etc.

**EQUIPMENT AND FACILITIES
SANITATION REPORT**

Time _____ Date _____ Line Number _____

Location in line _____

☐ Routine check

or

☐ Problem as follows _____

Appearance:

☐ Acceptable

☐ Unacceptable

Odor (if any):

☐ Acceptable

☐ Unacceptable

Bacterial Tests:

Total plate count _____/gm

Coagulase + Staphylococcus _____/gm

Remarks and Recommendations:

PERSONNEL INFRACTION REPORT

Date _____ Time _____ Location _____

Name or Number _____

Uniform: ☐ Dirty Hair Covering: ☐ Missing
 ☐ Missing ☐ Incomplete

Hands: ☐ Infections ☐ Chlorine or dip irritation☐ Smoking in the processing areas☐ Not sanitizing hands☐ Eating or gum chewing in the processing area☐ Return of dropped product to the line☐ Other (specify) _____

Action taken:

VITA

William Clifford Hopkins, Jr., was born in Lebanon, Kentucky, on January 25, 1944. He attended elementary school in Starkville, Mississippi. In 1955, he moved to Baton Rouge, Louisiana, where he completed his public school work by graduating from Robert E. Lee High School in 1962. In June, 1962, he enrolled in Louisiana State University, Baton Rouge, where he received his Bachelor of Science in Food Science in May, 1968. In September, 1968, he enrolled in the Department of Food Science at Louisiana State University as a graduate student. He received the Master of Science degree in 1970, and continued on toward the Doctor of Philosophy degree. During this time, he spent two and one-half years working for two of the larger seafood packers in the United States as director of Quality Assurance. He is presently a candidate for the degree of Doctor of Philosophy in Food Science.

EXAMINATION AND THESIS REPORT

Candidate: William Clifford Hopkins, Jr.

Major Field: Food Science

Title of Thesis: The Application of the HACCP Concept to the Breaded Shrimp Industry

Approved:

A. J. Novak

Major Professor and Chairman

James B. Ingram

Dean of the Graduate School

EXAMINING COMMITTEE:

J. B. Ford

Robert M. Godner

William H. James

Joseph A. Linze

M. R. Ran

Date of Examination:

November 26, 1975